U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-289 492

Report of the 4th CCMS (Committee on the Challenges of Modern Society) Solar Energy Pilot Study Meeting Held at Dusseldorf, Germany on April 17-18, 1978

NATO Committee on the Challenges of Modern Society, Brussels (Belgium)

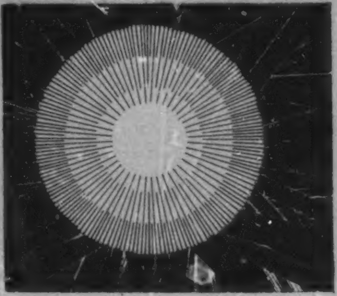
Prepared for

Department of Energy, Washington, DC

Aug 78

CCMS NO. 84/UMD-4908-12

PB 289492



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REPORT OF THE FOURTH CCMS SOLAR ENERGY PILOT STUDY MEETING

April 17-18, 1978
Düsseldorf, Germany

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NATO Committee on the Challenges of Modern Society
CCMS SOLAR ENERGY PILOT STUDY
Solar Heating and Cooling Systems in Buildings

United States Pilot Country
Denmark Co-Pilot Country
France Co-Pilot Country

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.
NATO/CCMS 84

2.

3. RECIPIENT'S ACCESSION NO.
PB289492

4. TITLE AND SUBTITLE
Report of the Fourth CCMS Solar Energy Pilot Study Meeting - April 17-18, 1978, Dusseldorf, Germany

5. REPORT DATE
August 1978

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
Sheila Blum and Redfield W. Allen, editors

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
University of Maryland
Department of Mechanical Engineering
CCMS Projects Office
College Park MD

10. PROGRAM ELEMENT NO.

11. CONTRACT/~~GRANT~~ NO.
EY 76-S-05-4908

12. SPONSORING AGENCY NAME AND ADDRESS
U. S. Department of Energy
Conservation and Solar Applications
Washington DC

13. TYPE OF REPORT AND PERIOD COVERED

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The Solar Energy Pilot Study of the NATO Committee on the Challenges of Modern Society (CCMS) was established with the objective of encouraging the cost-effective and practical application of solar energy to heating and cooling in buildings. Since 1974, four pilot study meetings have provided a forum for presentation of status reports of the various elements of the pilot study. This report is a summary of the fourth and final Solar Energy Pilot Study Meeting and contains, in addition to national program reports and progress reports on the sub-project activities, recommendations for continued international cooperation during the two-year CCMS follow-up period.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT

19. SECURITY CLASS *(This Report)*

20. SECURITY CLASS *(This page)*

21. NO. OF PAGES
159

22. PRICE
PC A08
MF A01

EPA Form 2220-1 (9-73)

UMD-4908-12/CCMS NO. 84

REPORT OF THE FOURTH
CCMS SOLAR ENERGY PILOT STUDY MEETING

APRIL 17 - 18, 1978
DÜSSELDORF, GERMANY

Edited by

Sheila Blum and Redfield W. Allen

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For the

U.S. Department of Energy
Conservation and Solar Applications
Washington, D.C. 20545, USA

Contract No. EY 76-S-05-4908

August 1978

i (a)

ABSTRACT

The Solar Energy Pilot Study of the NATO Committee on the Challenges of Modern Society (CCMS) was established with the objective of encouraging the cost-effective and practical application of solar energy to heating and cooling in buildings. Over twenty NATO and non-NATO countries have participated in the activities of this international cooperative program. The project has focused on exchange of information on (1) national solar heating and cooling programs in the participating countries and (2) solar heating and cooling projects, with emphasis on performance results. Two effective working groups have also been formed relating to regional applications of solar energy: The Zero Energy House Group and the Mediterranean Applications Group. Since 1974, four pilot study meetings have provided a forum for presentation of status reports on national solar heating and cooling programs and the review of the status of the various elements of the pilot study. The fourth and final Solar Energy Pilot Study Meeting was held at Dusseldorf, Germany in April 1978. This report is a summary of that meeting and contains, in addition to national program reports and progress reports on the sub-project activities, recommendations for continued international cooperation during the two-year CCMS follow-up period.

TABLE OF CONTENTS

Page

ABSTRACT ii

INTRODUCTION 1

AGENDA 3

OBJECTIVES OF THE MEETING 4

HIGHLIGHTS OF THE MEETING 5

REPORT ON ACTIVITIES OF THE PAST YEAR 6

COMMENTS BY U. S. CCMS COORDINATOR 9

STATUS REPORTS ON NATIONAL SOLAR HEATING AND COOLING PROGRAMS 10
    Australia 17
    Belgium 22
    Canada 25
    Denmark 30
    France 34
    Federal Republic of Germany 50
    Israel 57
    Italy 60
    Luxembourg 65
    Monaco 66
    New Zealand 68
    Spain 73
    Sweden 75
    Turkey 79
    United Kingdom 86
    United States 92

REPORT OF THE ZERO ENERGY HOUSE GROUP 109

REPORT OF THE MEDITERRANEAN APPLICATIONS GROUP 114

REPORT OF THE SYSTEM REPORTING FORMAT COMMITTEE 119

FOLLOW-UP RECOMMENDATIONS 123

CCMS/ISES TECHNICAL CONFERENCE 126

APPENDIX ....

    A. LIST OF MEETING PARTICIPANTS 130
    B. CONTACT PERSONS 133
    C. CENTRAL INFORMATION CONTACTS 136
    D. MEMORANDUM OF UNDERSTANDING 137
    E. CCMS SYSTEM REPORTING FORMAT 139
    F. CCMS FORMAT SUMMARY OUTLINE 145
    G. SYSTEM REPORTING FORMAT COMMITTEE 149
    H. REPORTS EXCHANGED 150

INTRODUCTION

NATO COMMITTEE ON THE CHALLENGES OF MODERN SOCIETY

The Committee on the Challenges of Modern Society (CCMS) was founded in 1969 as an initiative of the President of the United States to provide a "social dimension" to the North Atlantic Alliance. With the increasingly complex technological and environmental problems challenging industrialized societies--issues such as population, food and raw materials, air pollution, water pollution, energy, wastewater treatment, health care, disaster assistance, treatment of hazardous substances, etc. -- the North Atlantic Alliance members recognized the need for an effective mechanism for sharing their economic and technological strengths in order to respond to the environmental, technical, and social challenges that confront them. CCMS has been instrumental in defining these challenges and in finding responses to them.

CCMS initiated the pilot study method, in which a lead country, in association with other interested countries, rather than an International Secretariat, conducts a project in an area of common interest. There are currently 13 CCMS pilot studies in which all NATO countries are actively participating. CCMS projects are open to interested non-NATO countries, and the Committee's projects have generated wide interest and participation around the world. Australia, El Salvador, Israel, Japan, New Zealand, the Philippines, Saudi Arabia, Spain, and Sweden are among those countries working with the NATO members on CCMS pilot studies.

CCMS has been recognized as an effective mechanism for meeting the imperatives of energy development and conservation, and it was the first international organization to deal with these problems. By late 1973, CCMS had initiated pilot studies in solar and geothermal energy, and shortly thereafter, in the rational use (conservation) of energy.

SOLAR ENERGY PILOT STUDY

The objective of the CCMS Solar Energy Pilot Study is the exchange of information on the solar heating and cooling systems programs and projects of each participating country so as to encourage the cost-effective and practical application of solar energy to heating and cooling in residential, commercial, industrial, agricultural, and public buildings. The key elements in this information exchange are:

1. The participation in pilot study and subgroup meetings for the review of research and development programs and experimental projects and the exchange of information and ideas.
2. The preparation and distribution of system performance reports, prepared in an agreed format, on solar heating and cooling projects in participating countries.

3. The exchange of relevant and publically available reports concerned with solar heating and cooling systems in buildings.

The guidelines for the pilot study are contained in a Memorandum of Understanding (see Appendix D) which has been signed by fifteen of the participating countries. Eight additional countries plus the European Commission participate as observers, some quite actively, and all 24 countries have designated contact persons through whom all information is exchanged.

The pilot country for the CCMS Solar Energy Pilot Study is the United States and the co-pilot countries are Denmark and France. The responsible agency in the United States for this pilot study is the U. S. Department of Energy. Dr. Frederick Morse, Chief of the R&D Branch for Heating and Cooling, Office of the Assistant Secretary for Conservation and Solar Applications, is the director of the CCMS Solar Energy Pilot Study. Support is provided by Dr. Redfield Allen and Ms. Sheila Blum of the CCMS Projects Office at the University of Maryland.

During October 1974, representatives from seventeen countries met at the CNRS Solar Energy Laboratory at Odeillo, France, in the first annual meeting of the CCMS Solar Energy Pilot Study. The second annual meeting, attended by the representatives from twenty-two countries, was held in Palo Alto, California, in August 1975. The third meeting of the CCMS Solar Energy Pilot Study was held September 1976 in Copenhagen, Denmark.

DÜSSELDORF PILOT STUDY MEETING

This report is a summary of the fourth Solar Energy Pilot Study Meeting, which took place in Düsseldorf, Federal Republic of Germany on April 17-18, 1978. Delegates from sixteen countries plus the European Commission and NATO participated in the meeting. Presentations were made on the status of national Solar Heating and Cooling programs, and reports given on the progress of various elements of the project. Furthermore, as this was the final meeting of the Solar Energy Pilot Study prior to initiation of a two-year follow-up phase, extensive discussions were held to formulate recommendations for continuation of the cooperative activities initiated by this study.

A CCMS-sponsored technical conference was held in conjunction with the pilot study meeting on April 19-20, 1978. The proceedings of this International Conference on the Performance of Solar Heating and Cooling Systems were published by the Federal Republic of Germany. Additional information on the conference is found elsewhere in this report.

ACKNOWLEDGEMENTS

The 1978 Solar Energy Pilot Study Meeting was ably hosted and organized by the Kernforschungsanlage-Jülich. The fine efforts of Ing. Franz Friedrich, Dr. Felix Peuser, their staff, and Dr. Ingrid Rose-Neiger are sincerely appreciated.

AGENDA

FOURTH CCMS SOLAR ENERGY PILOT STUDY MEETING

April 17-18, 1978
Düsseldorf, Germany

MONDAY, APRIL 17

8:30 - 9:30	Registration
9:30 - 12:30	Morning Session - Chairman: M. Rodot, France Introductory Remarks - F. Morse Report on Activities of the Past Year - S. Blum Status of the Memorandum of Understanding - P. Ward Report of the Zero Energy House Group - V. Korsgaard Report of the Mediterranean Applications Group - M. Rodot Report of the System Reporting Format Committee - R. Allen
12:30 - 14:00	Lunch
14:00 - 17:00	Afternoon Session - Chairman: F. Morse, United States Discussion on Future Course of Pilot Study Activities
20:00	Banquet (Parkhotel) - Hosted by German Section of ISES and Arbeitsgemeinschaft Solarenergie e. V. (ASE)

TUESDAY, APRIL 18

9:00 - 12:30	Morning Session - Chairman: V. Korsgaard, Denmark Presentations on National Solar Heating and Cooling Programs
12:30 - 14:00	Lunch
14:00 - 16:00	Afternoon Session - Chairman: V. Korsgaard, Denmark Continuation of National Program Presentations
16:15 - 17:15	Concluding Discussion and Remarks - Chairman: F. Morse, U.S.
17:30	Reception - Hosted by U.S.

POST MEETING TOUR

FRIDAY, APRIL 21

Visits to the Dornier-RWE Solar House in Essen and the Philips Experimental House in Aachen.

OBJECTIVES OF THE MEETING

The objectives of the 1978 CCMS Solar Energy Pilot Study Meeting were:

- To review the activities of the CCMS Pilot Study since the 1976 Copenhagen meeting.
- To provide the participants with an up-to-date description of the status of the solar heating and cooling programs in the participating countries.
- To hear the report of the System Reporting Format Committee and discuss the System Reporting Format and Format Summary Outline.
- To hear the reports of the Zero Energy House Group and Mediterranean Applications Group.
- To provide an open forum for the participants to exchange ideas on the activities of this CCMS Pilot Study.
- To discuss the future course of the project and its activities.

HIGHLIGHTS OF THE MEETING

- Thirty-five delegates from sixteen countries plus the European Communities and NATO participated.
- Reports were presented by sixteen countries on their national programs or activities in solar heating and cooling for buildings. These reports reflected significant expansion of activities in the various countries since the previous meeting.
- The recent meetings of the Mediterranean Applications Group and Zero Energy House Group were reported.
- The final CCMS versions of the System Reporting Format and Format Summary Outline were agreed to and the mechanism for further modification within the IEA accepted.
- Extensive discussions were held on the future of the pilot study and framework for continuation of its activities during the CCMS follow-up period.
- Appreciation for the effectiveness and positive impact of this cooperative program was expressed by the participants.

REPORT ON THE ACTIVITIES OF THE PAST YEAR

Sheila Blum
Department of Mechanical Engineering
University of Maryland

The North Atlantic Treaty Organization's Committee on the Challenges of Modern Society has supported the concept of multinational cooperation in order to formulate coordinated, effective methods for dealing with modern technological and environmental problems. At an early date, the CCMS recognized the need to deal with the imperative of diminishing supplies of fossil fuels and their rising costs. As a result, CCMS established four pilot studies in the energy area - solar energy, geothermal energy, rational use of energy, and advanced automotive propulsion systems.

At its inception in 1973, it was determined that the scope of the Solar Energy Pilot Study would be exchange of information on solar heating and cooling systems in buildings, with the objective of encouraging cost-effective and practical implementation of this technology in the participating countries. According to the Memorandum of Understanding, which contains the framework and general guidelines for this pilot study, the information exchanged is to consist of details of the national solar heating and cooling programs of the participating countries and information on specific projects, especially systems performance data. The exchange is carried out through participation in meetings and distribution of solar heating and cooling reports.

From that beginning in 1973, the program has grown to a pilot study of 24 participating countries, comprised of both NATO and non-NATO countries, since CCMS pilot studies are open to all interested nations. Fourteen of these countries are signatories of the Memorandum of Understanding and the remainder participate as unofficial or observer members. As part of the information exchange activities three pilot study meetings have been held, two specialized sub-groups successfully established and many reports disseminated. I will report briefly on the major activities and achievements since the last Solar Energy Pilot Study meeting which was held in September 1976 in Copenhagen.

Since the last meeting, New Zealand and Spain have signed the Memorandum of Understanding. The total number of signatories now stands at fourteen.*

The Mediterranean Applications Group, formed in Copenhagen, held its first meeting in October 1977 in Nice, under the chairmanship of France, a co-pilot country. The meeting was attended by 30 representatives from nine countries plus the European Commission. Among the topics discussed relating to solar energy in Mediterranean-like climatic regions were passive heating and cooling techniques and traditional regional architecture and its suitability or adaptability to passive and active solar systems. A more complete report on the Mediterranean Applications Group will be presented this morning by its chairman, Dr. Rodot.

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*The Netherlands signed the Memorandum of Understanding in April 1978, bringing the total to fifteen.

The Zero Energy House Group was formed in 1974 to enable experts to exchange information on solar-assisted low-energy projects, especially in northern-European type climates. This group, under the chairmanship of the other co-pilot country, Denmark, held its third meeting at Stockholm in December 1977, with nineteen representatives from seven countries participating. Many participants in this group have expressed appreciation for the opportunity that this project provides for detailed interchange on specific projects and their performance results, and they have emphasized their desire to continue the group's activities. A more detailed report on the Zero Energy House Group will be presented this morning by Professor Korsgaard.

The Zero Energy House Group and the Mediterranean Applications Group are examples of how the information exchange--outlined in general form in the Memorandum of Understanding--has been successfully expanded to encompass specialized areas of solar heating and cooling. These groups permit solar experts to become informed about similar projects in other participating countries and to exchange views on successes, problems, and new directions in these solar applications.

A CCMS System Reporting Format was developed and adopted by the pilot study in 1975. It is intended that this reporting format be used for the preparation of system performance reports (or "Special Format Reports") on operating solar systems. At the Copenhagen meeting, it was recommended that the special format reports would benefit from the inclusion of a format summary which would serve as an extended abstract. For this purpose, Redfield Allen, Chairman of the System Reporting Format Committee, drafted a format summary outline, which was distributed to the committee members and to all contact persons. He will present a report this morning, and delegates will have the opportunity to discuss both the reporting format and the summary outline.

The exchange of system performance reports began somewhat slowly. This has probably been due in large measure to the fact that until recently only a few projects had been in operation sufficient time to provide the extensive performance data required by the reporting format. This picture is now improving and recent efforts have been directed to preparation of a significant number of system performance reports for the CCMS International Solar Energy Conference on April 19-20.

The Memorandum of Understanding states that, in addition to system performance reports, reports of general interest on solar heating and cooling of buildings are to be exchanged. Since the September 1976 Copenhagen meeting, over 40 such reports have been distributed by nine countries. I believe that these reports have been well received and were useful to the member countries, and thank those participants who distributed those excellent documents. Continued exchange of reports is encouraged, as well as the participation of those countries which have not yet contributed.

At the Copenhagen meeting, the participating countries agreed on the desirability of designating a central information agency or person to assist in the internal dissemination of reports exchanged under this pilot study. Following that meeting, contact persons were asked to designate such an information contact, and twelve countries did so. It is hoped that this addition has enhanced the information exchange by making these exchanged reports more readily available to members of the solar research and planning community in each country.

The fourth Solar Energy Pilot Study Meeting is now underway, and important reports and discussions will take place during these two days. As in the past, we will review the national solar heating and cooling programs and projects of the participating countries. These reports allow each delegate to view the program and activities of his country against those of other countries and to note opportunities for expansion or strengthening of national programs. It also enables participants to note areas of solar energy utilization suitable for possible bilateral or multilateral cooperation in order to prevent duplication of efforts or to benefit from the particular expertise of one or more countries.

During this meeting, we will also discuss the future of the activities initiated under this program. CCMS pilot studies are intended to be of limited duration, and the participating countries must now determine what action they wish to take regarding continuation of the various elements of the program. A letter outlining the recommendations of the pilot and co-pilot countries were distributed to the contact persons, prior to this meeting, for their consideration.

I anticipate that the International Solar Conference on April 19-20 will be an outstanding meeting, thanks to the authors from ten CCMS countries who have prepared presentations, and especially to the host organizers who have put a great deal of effort into planning this conference. Seventeen system performance reports, representing a wide variety of solar heating and cooling applications, will be presented. The proceedings of the conference, containing performance reports prepared in accordance with the CCMS System Reporting Format, will be given wide distribution and will certainly be considered an important contribution of this program. The international conference, which will allow interested members of the solar community to learn of the performance results of many significant solar heating and cooling research projects is, in a sense, a culmination of the system performance exchange activity undertaken by this pilot study.

In summary, a number of important activities and accomplishments have taken place since the last meeting. By sharing efforts and expertise, this pilot study has made valuable contributions to the advancement of solar energy utilization.

COMMENTS BY U.S. CCMS COORDINATOR

Paul Von Ward
Environmental Protection Agency, USA

MEMORANDUM OF UNDERSTANDING (MOU)

Two additional countries-Spain and New Zealand-signed the MOU since the last pilot study meeting. It should be noted that the agreement is still open for signature. During the meeting, both Turkey and The Netherlands expressed intention to sign the MOU in the near future. (Ed. Note: The Netherlands signed the Memorandum of Understanding on April 28, 1978.)

FINAL REPORTS OF THE FOUR ENERGY PILOT STUDIES

The U.S., as the lead country for four CCMS energy studies, plans to make an integrated presentation of the final reports on the Solar Energy, Geothermal Energy, Rational Use of Energy, and Automotive Propulsion Systems Pilot Studies at the October 1978 Plenary session of CCMS. The final reports will serve as a basis for a general CCMS discussion of energy issues and future energy-related activities in the CCMS work program. U.S. and Italian plans are underway to hold a July 1978 workshop in Italy, involving key participants in the four pilot studies and other energy experts, to develop an integrated scenario and materials for the Fall Plenary presentation. The objective of the workshop will be to look at the implications of all four studies for future national and international energy policies and programs.

As this is the final meeting of the pilot study, it is important that the delegates arrive at a set of general conclusions about follow-up activities during the two-year period required by NATO-CCMS that will reflect the variety of stages of development of the study's sub-projects and their relationship to other relevant international activities. CCMS is very flexible in the approach that may be used to follow-up on the work done by a pilot study and it can include the involvement of other international organizations.

NATIONAL PROGRAMS: SOLAR HEATING AND COOLING IN BUILDINGS

INTRODUCTION

One of the major activities of the CCMS Solar Energy Pilot Study has been the exchange of information on the national solar heating and cooling programs of the participating countries. This is accomplished through the presentation of status reports at the pilot study meetings and the compilation and distribution of this program information in the proceedings of the meetings. Since the inception of the project, four Solar Energy Pilot Study Meetings have been held:

- Odeillo, France, October 1974
- Palo Alto, California, U.S.A. - August 1975
- Copenhagen, Denmark - September 1976
- Düsseldorf, Germany - April 1978

The presentations on national solar heating and cooling programs and projects have allowed the participants to view their own activities against those of other countries and to note opportunities for strengthening of their own programs. In addition, the reports pointed up opportunities for closer cooperation (both within and apart from the pilot study), in order to avoid duplication of efforts and to facilitate sharing of expertise and experience. Two examples of specialized cooperative interchange are the Zero Energy House Group and the Mediterranean Applications Group, which were established when it became evident, from the program reports at the earlier pilot study meetings, that certain groups of countries were stressing similar solar applications.

The successive status reports have reflected a significant increase, since the initiation of the pilot study, in the number of countries having formal solar energy programs and, in all cases, activities in the area of solar heating and cooling for buildings have greatly expanded. This changing status is noted in Table 1. The current emphasis of the solar heating and cooling activities of the countries represented at the Düsseldorf meeting is summarized in Table 2. The full reports on the national solar heating and cooling programs follow these tables.

The information provided by the CCMS exchange on national solar heating and cooling programs has clearly influenced the direction taken by many programs and contributed to the expansion and acceleration of these programs. The participating countries have indicated that they have found this aspect of the pilot study to be most valuable and have recommended that this activity be continued through presentations at the biannual meetings of the International Solar Energy Society.

Table 1
SUMMARY OF THE STATUS OF THE SOLAR HEATING AND COOLING IN BUILDING PROGRAMS OF THE SIGNATORY COUNTRIES

COUNTRY	1974 (Odeillo) STATUS	1975 (Palo Alto) STATUS	1976 (Copenhagen) STATUS	1978 (Dusseldorf) STATUS
Australia	No formal program - many projects underway.	No formal program - many projects underway.	No formal program - many projects underway.	RD&D supported by national and state governments. National program expected to be developed.
Belgium	Program being formulated.	Program initiated.	Program underway and several projects initiated.	Initial 3-year nationally funded R&D program nearing completion.
Canada	Need for solar not established.	Program initiated and several projects started.	Program underway with increased funds and projects.	R&D program continues with 8-fold increase in funding since 1976.
Denmark	Program underway involving several projects.	Program underway involving several projects.	Expanded program underway.	Increased funding and additional projects in national program.
Federal Republic of Germany	Program initiated - several projects underway.	Program significantly expanded.	Program continues to expand significantly.	Large scale program for R&D and government support of industry.
France	Program being formulated-several projects underway.	Program initiated and projects significantly expanded.	Program continues to expand significantly.	Solar Energy Agency established to coordinate large national program and government and private projects.
Greece	No formal program.	Program initiated.	Limited program underway.	
Israel	No formal program.	Program initiated and several projects started.	Program underway with initiation of new projects.	Program continues government supported research by universities and industry.
Italy	Program being formulated.	Program initiated - several industrial projects underway.	Not present.	Expanded CNR program with increased funding.

COUNTRY	1974 (Odeillo) STATUS	1975 (Palo Alto) STATUS	1976 (Copenhagen) STATUS	1978 (Dusseldorf) STATUS
Jamaica	Observer.	Program being formulated.	Not present. Limited program initiated.	Limited program continuing.
The Netherlands	No formal program- Several projects being initiated.	Program being formulated - additional projects underway.	Program being formulated - projects continuing.	Expanded funding and RD&D activities. Formal program to be initiated shortly.
New Zealand	Not present.	No formal program.	Not present.	No formal program, but government support of R&D activities.
Spain	Not present.	Program being formulated.	Program being formulated - several projects underway.	National coordination of funding and expanded activities underway. Formal program to be initiated in 1979.
United Kingdom	No formal program - several projects underway.	No formal program - additional projects initiated.	Not present.	Four year government program underway.
United States	Program underway involving many R&D and demonstration projects.	Significant growth in program.	Significant growth continues.	Further expansion of large, multi-faceted program, with emphasis shifting towards accelerating the commercialization of solar systems.

Table 2
CURRENT EMPHASIS OF THE SOLAR HEATING AND COOLING
IN BUILDING PROGRAMS OF THE PARTICIPATING COUNTRIES

AUSTRALIA	Priority in energy research is being given to projects which will either conserve or replace oil. Solar heat generating systems have been developed to the stage where they can now be used on a large scale for industrial process heating and heating and cooling of homes and offices which are the most promising applications. Research, development and demonstration (R D & D) programs are supported by the Australian Government and the State Government of Victoria, South Australia and Western Australia. The work is carried out in CSIRO and a number of universities and colleges of advanced education. A demonstration installation is in operation in a soft drink factory and others are either under construction or being planned. These will show what can be done now with known technology and enable performance to be measured under operating conditions. Annual expenditures for R D & D in 1977/78 is about $2 million.
BELGIUM	A nationally funded R & D program to study the feasibility of solar energy for space and water heating is nearing the end of its first three-year period. In the same area of applications, research is being conducted as part of EEC and IEA energy programs. This work is being done at the Katholieke Universiteit Leuven and at the Faculte Polytechnique de Mons. Some emphasis is also being placed on solar-assisted heat pump systems, hybrid photovoltaic-thermal solar systems, chemical reaction storage, and collector testing procedures.
CANADA	A new Solar Energy Projects Office within the NRC has been established to administer the federal solar heating program which has had an eight fold increase in funding since 1976. Major supported activities include feasibility studies, development of a solar data base, R & D projects and a demonstration program. Earlier support for demonstration of solar systems in detached homes has expanded to solar space and/or service hot water heating for multi-unit residential buildings and next year will include non-residential buildings. A wide variety of component and system R & D studies are underway, both at the NRC and by contractors. Several provincial governments have their own solar energy program as well. Between 15-20 small companies are manufacturing Canadian solar collectors.
DENMARK	For a five-year period, $6 million have been allocated for solar heating R and D and a low-energy housing program. 15 industry and government sponsored demonstration projects are being monitored. A total of about 5000 m^2 of solar collectors have been installed in private homes. The research program includes the following projects: outdoor test stand for solar collectors, indoor solar simulator, test facilities for solar heating

Table 2 continued

	systems, solar energy storage in the ground, experimental investigation of a full scale heat storage with salt hydrate based on the extra water principle, and solar-powered solid-absorption refrigeration system for developing countries.
FRANCE	The French program for solar heating and cooling of buildings is essentially made up of four elements: (1) the CNRS research program (physiology of comfort, system modelling and experimentation, collection and storage components, cooling); (2) the Plan-Construction (Ministry of Equipment) research and experimentation program (thermal storage, climatology, architecture of dwellings and urban shapes, improvement of existing buildings, experimentation of a collective dwelling); (3) the demonstration program of the Delegation aux Energie Nouvelles (Ministry of Industry) which amounts to 25 MF in 1978, for funding of residential and non-residential projects; and (4) some private programs such as those of St. Gobain, COSTIC and Compagnie Francaise de Raffinage. The total budget is approximately 60 MF for 1978, i.e., one third of the total national budget for solar energy R & D. Effective May 1978, a new "Commissariat a l'Energie Solaire" coordinates the national solar program.
FEDERAL REPUBLIC OF GERMANY	By December 1977, the industry-based and government cost sharing solar energy programme had expanded to 53 projects -- 32 related to hot water supply and heating of buildings. Sixteen buildings with extensive data acquisition and evaluation systems are in operation. More than 100 firms are marketing hot water and heating systems. Several fiscal support actions facilitating the installation of solar systems in private and governmental buildings have become effective. Research activities are focused on the development of durable selective surfaces and on the establishment of standardized qualification methods for solar energy components, including system safety.
ISRAEL	Government supports industry 50% in 20 projects in hardware development, large-scale solar water heating systems, materials technology (selective surfaces, plastics), and bio-processes (conversion of agricultural wastes and development of halophylic algae as a fuel source). Two "national" projects (80% support) continue, one for development of solar climate control including cooling machines and one on solar ponds for temperatures up to 100°C for heating, cooling and other uses. Exploratory R & D (100% support) is also conducted on collectors, greenhouses and non-SHCB applications such as photovoltaics and photochemistry.
LUXEMBOURG	Solar Energy research was initiated by Luxembourg industry in 1974. Government has been supporting industry R & D for solar collector development and solar-assisted heat pump systems since 1976.

Table 2 continued

MONACO	Local industry is developing and testing 2 types of concentrating, tracking collectors and 1 non-imaging concentrating collector. Design and testing of vacuum insulated tubes for these collectors is underway, as well as high temperature storage systems.
NEW ZEALAND	The New Zealand climate and the pattern of energy use has dictated that domestic solar water heating should be the first topic for Government sponsored solar research. Modelling and computation of domestic solar water heater performance in all major NZ towns was completed in 1965. Testing of solar collectors and solar water heating systems continues. Space heating on a single-house scale is not favoured because of the small energy demand, but centralised space and water heating in the domestic and industrial sectors is being investigated. Thus, solar energy is diverted towards providing low grade heat so that high grade energy (electricity) currently used for this purpose can be freed for more demanding purposes.
SPAIN	Since 1977 activities in solar energy have been coordinated and financed through the Centro de Estudios de la Energia (CEE). A national program is being prepared for 1979 with an estimated budget of 400 MPta (25M $), with about 15% devoted to heating and cooling projects. The CEE is conducting a survey study to identify industrial applications of solar energy, and demonstration projects are being planned. Other institutions -- INTA, Services Meteorologie Nacional, SCIC and INI -- are also involved in solar energy projects. Private industry activity in solar energy is expanding with about 20 firms currently engaged in this trade. An 18-story building with 10,000 m^2 of floor area incorporating 1,800 m^2 of vertical active air collectors began operation in October 1977.
SWEDEN	A solar R & D and demonstration program will be included in national energy program for 1978-81. Heating of swimming pools and hot water heating are first option of interest. Five solar heated outdoor public swimming pools will be sponsored and evaluated. At least two large-scale (more than 50 dwellings) solar space heating systems based on central seasonal thermal storage will be built during program period.
TURKEY	The solar energy program, initiated in 1976, is coordinated by Ministry of Energy and Natural Resources and carried out by the Mineral Exploration and Research Institute at "Marmaris Solar Energy Research Center." The major project at the Research Center related to solar heating and cooling of buildings has four phases: heating of two types of village houses and heating and cooling of single-family and apartment dwellings. The first phase of the project has been in operation since September 1977. Additional activities continue on collection of climate and solar data, solar drying, greenhouse heating, solar collectors, development of selective surfaces, and solar distillation. Scientific and applied research carried out at universities and research institutions include solarimetry studies, testing of

Table 2 continued

	buildings solar drying, desalinization, architectural research, solar collectors, energy storage, and solar cells.
UNITED KINGDOM	Government Departments in the United Kingdom are collaborating in a four-year programme aimed at the comprehensive assessment of the contributions likely to be made to national energy supplies by the exploitation of solar technology, against alternative rates of rise in world energy prices. Low-grade thermal applications are foreseen as the most significant uses of solar energy in UK, and the greater part of the £6 million programme announced in February 1977 by the Department of Energy is likely to be devoted to space and water heating in buildings. Other Central Government funds are being made available by the Department of the Environment (with its own solar research facilities at the Building Research Station), the Department of Industry, and the Science Research Council. At least 40 projects in this field are in progress at universities, government laboratories, local authorities and commercial enterprises; Government participation varies from co-ordinating discussion of results, to full funding of costs.
UNITED STATES	The goal of the U. S. Solar Heating and Cooling Program, directed by the Department of Energy, is the advancement of industrial, commercial and professional capability for producing and distributing solar energy systems, thus reducing the demand on fossil fuel supplies. The major elements of the heating and cooling program are: research and development; residential and commercial demonstrations; agricultural and industrial applications; federal buildings program; technology transfer; and commercialization. The R & D program has expanded to 244 projects, most of which are aimed at improved performance and cost-effectiveness. The four cycles of demonstration awards have funded several hundred residential and commercial projects. Strong emphasis has recently been placed on market development to accelerate the commercialization of solar heating and cooling.

AUSTRALIAN PROGRAMME FOR SOLAR HEATING AND COOLING

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Solar Energy Studies

INTRODUCTION

Australia is a net exporter of energy by a small margin, the exports of coal in energy terms annually slightly exceeding its imports of oil. Local oil production, at present about 70% of requirements, is unlikely to be able to keep pace with the increasing demand, and it is forecast that by 1985 this figure will have dropped to about 25%, Since the balance will have to be imported, at a time when it is forecast that world demand for oil will exceed supply, the top priority in energy research is going to projects which will either conserve or replace oil. The primary energy input to the Australian economy is as follows: oil 48%; coal 40%; natural gas 7%; miscellaneous 5% (2% hydro-electric, 2% bagasse, 1% wood). Energy usage is shown in Table 1, from which it can be seen that less than 4% of primary energy is used in homes. Even if the primary energy required for the generation of electricity is added to this, the total is small compared to the primary energy used in industry, which accounts for some 40% of the total.

The existing solar collector industry is based predominantly on solar water heaters for residential applications, and there are probably between 100,000 and 150,000 m^2 of collectors installed for this purpose at the present time. Although their contribution to annual primary energy is very small (about 0.1%) they could eventually contribute perhaps 1% or 2% of the national total. It is clear that the way solar energy can make a major contribution to Australian primary energy is in industry.

Natural gas is being developed from recently discovered fields, and will be able to replace oil for many industrial applications. It is eventually expected to provide about 20% of the nation's primary energy, but is only expected to last about 50 years.

Electric power generation is predominantly coal based, and Australian reserves of coal are very large, and it is assumed that primary energy for electric power generation is secure for as far ahead as can be foreseen. There is, however, a small demand for electric power supplies of a few kilowatts in remote areas which could possibly be supplied from solar energy.

The most promising prospects for large scale solar energy applications are, however, for industrial process heating systems, together with the heating and cooling of homes and offices, which ultimately might reach a total of 1.5 EJ per annum.

TABLE 1: ESTIMATED AUSTRALIAN PRIMARY ENERGY USAGE 1974-5

	$J \times 10^{15}$	%	
Agriculture, forestry and fishing	58	2.1	Total "Manufacturing" 40%
Mining	74	2.6	
Food, beverages and tobacco	95	3.4	
Paper	29	1.0	
Chemicals	34	1.2	
Petroleum refining	135	4.8	
Non-metallic minerals	102	3.6	
Iron-steel	387	13.7	
Non-ferrous metal	147	5.2	
Manufactured goods	47	1.7	
Construction	20	.7	
Wholesale-retail	37	1.3	
Domestic	103	3.7	
Transport and storage	702	24.9	
Electricity (including hydro 46)	795	28.3	
Gas distribution	37	1.3	
Others	13	0.5	
	2815	100	

Source: Department of Minerals and Energy

ACTIVITIES OF LEARNED SOCIETIES

The Institution of Engineers, Australia, the largest of the Learned Societies, in 1975 set up an Energy Task Force to examine and report on Australia's energy problems. It consisted of 12 Working Parties, one of which covered solar energy, and reported its findings to a National Conference in July 1977 (1). A summary was subsequently published entitled "Recommendations for an Energy Policy for Australia" (2).

The Solar Energy Working Party made specific recommendations for the adoption of policies that would lead to the Australian energy economy being based on coal, solar energy and natural gas. It also reviewed the current state of the art, and suggested areas for research, development and demonstration. It suggested that the broad objectives of an Australian solar R, D & D programme could be as follows:

(a) Demonstrate how the application of existing knowledge can replace oil, conserve natural gas, and conserve coal.

(b) Develop and test new techniques and provide data which can extend the range of existing applications and/or improve their energetic and cost effectiveness.

(c) Study areas of application which offer the best potential and where research may be most effective in introducing new applications.

(d) Establish and maintain contact with solar energy research throughout the world.

The Australian and New Zealand Section of The International Solar Energy Society (ISES) in conjuction with the Australian and New Zealand Association for the Advancement of Science (ANZAAS) have published a series of papers (3) to (9) which will be the subject of a one-day conference in Sydney in May. This conference will be a further stage in the current debate from which a national energy policy could emerge.

GOVERNMENT INITIATIVES

The Australian Minister for National Resources has established a National Energy Advisory Committee which has set up a number of specialist panels to report to it. However, under the Australian Constitution, energy is one of the residual responsibilities which remain with the States. At the present time, three States have acted to promote solar energy R, D & D. Western Australia has established, as a statutory body, The Solar Energy Research Institute of Western Australia (SERIWA), Victoria has appointed a Solar Energy Research Committee to advise its Minister for Minerals and Energy, and the South Australian Minister for

Mines and Energy recently announced grants for solar R, D & D recommended by his Energy Advisory Committee. Both New South Wales and Queensland are moving in this direction, so it is likely that the Federal Government and all mainland States will become directly involved in solar R, D & D in the immediate future. This is an encouraging development, but it raises problems of co-ordination. The Institution of Engineers, Australia, Task Force, in its recommendations for an energy policy for Australia (2), sees this as a matter affecting all energy research, and suggests the formation of an Australian Energy Council supported by an expert advisory committee composed of representatives of statutory energy authorities. This whole question is under active debate at the present time.

RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMMES

Australian solar energy research is not co-ordinated on the national scale. The work is being undertaken in the CSIRO Divisions of Mechanical Engineering, Mineral Chemistry, Chemical Technology, Applied Organic Chemistry, Plant Industry, and its Solar Energy Studies Unit. Universities which have active programmes include the James Cook University of North Queensland, the Universities of Queensland and New South Wales, Sydney University, Universities of Melbourne, Adelaide, Western Australia and the Australian National University. Some colleges of advanced education also have small programmes, notably the Capricornia College of Advanced Education, the New South Wales Institute of Technology, the South Australian Institute of Technology and the Western Australian Institute of Technology. The current projects include the thermal rating of collectors, the development of improved collectors, particularly in the 60-150° range, the study of selective surfaces and the development of new and improved surfaces, high temperature concentrating systems, building heating and cooling, the measurement of the performance of solar heat generating systems, both in the laboratory and in the field, systems simulation, systems synthesis and optimization, drying and dehydration, the influence of large-scale solar water heating on electric power systems, the accumulation of data for design of solar systems, particularly solar radiation data and performance of flat plate collectors, small-scale electric power generation, and renewable fuels from plant material.

R, D & D expenditure for 1977/78 is something less than $2 million including the various State activities.

Development and Demonstration installations are being arranged by CSIRO through its Solar Energy Studies Unit, the first of which has been operating in Queanbeyan since January 1977, and was described in the CCMS/ISES conference (10). It has 94 m^2 of collector, a 20 m^3 thermal store, and supplies process heat to a can warming machine in a soft drink factory. A second installation is currently under construction in Adelaide, South Australia, in a brewery. It has 200 m^2 of collector, 48 m^3 of store and provides process heat to a beer pasteurizing machine.

The purpose of these Development and Demonstration installations is as follows:

1. To demonstrate in a factory environment, a solar process heating system which has been developed to the stage where it can operate without special supervision.

2. To identify, and, if possible, solve any problems which arise.

3. To provide an interface for technology interchange between researchers, the engineering industry and the factory management and operating staff.

4. To measure the performance of the system under operating conditions and determine its cost effectiveness in the light of both present and future energy costs.

Development and Demonstration installations are proving valuable as a means of promoting an awareness of the large scale prospects for solar energy utilization, and identifying areas for further Research and Development.

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SOLAR ENERGY PROJECTS IN BELGIUM

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NATIONAL ENERGY R & D PROGRAMME

The national Energy Research and Development Programme contains two studies of thermal applications of solar energy in Belgium, one at the Faculte Polytechnique de Mons (FPM) and the other at the Katholieke Universiteit te Leuven (K. U. Leuven). Both studies began in September 1975 and will end in August 1978.

STUDIES AT THE FACULTE POLYTECHNIQUE DE MONS

The research conducted by the team at FPM consists of:

- A study of flat plate solar collectors in which emphasis is placed on collectors using a liquid as heat transport medium. In this work the performance of the collectors is determined both theoretically and experimentally.

- Study of solar hot water systems: Dynamic performance models of solar hot water systems with forced circulation are developed, based upon observations on an experimental system. Systems with once-through auxiliary heaters and with split boilers (with one reservoir kept at the desired temperature) are investigated.

- Study of solar heating systems: The performance of solar heating systems, under Belgian climatological conditions, is studied by means of models making use of the degree-day method. Systems with conventional back-up heating are considered. A system is also studied in which a heat pump replaces the auxiliary heater. Only systems using liquid collectors are considered. A reduced-scale solar heating systems is being designed to verify the results obtained by means of the theoretical models.

- Study of a Belgian solar house: The architectural design has been made of a solar house adapted to the local climate. Part of the heating and hot water needs are to be provided by the sun. 70 m^2 of collector area and two storage reservoirs (5 m^3 and 50 m^3) are incorporated in the house.

STUDIES OF THE KATHOLIEKE UNIVERSITEIT DE LEUVEN

- Theoretical and experimental study of the performance of flat plate collectors: Considerable attention is devoted here to air collectors. An experimental study of the improvement of the performance of air collectors is being performed.

- Study of hot water systems: The performance of a natural circulation system (thermosyphon) for producing hot sanitary water in Belgium is being investigated. The performance calculations are based upon a dynamic model of the system verified on an experimental full-scale loop (14.2 m^2 collector area, 300 l boiler volume).

- Study of solar heating systems: In contrast with the work done at the FPM, the team at the K.U. Leuven considers air systems, making use of air collectors and rock-bed storage. Dynamic models are developed for the air systems based upon observations on a reduced scale experimental loop (15.6 m^2 collector area, 2 m^3 brick storage) built especially for this purpose.

- Study of hybrid solar systems: Research is conducted on the performance of solar systems which make use of collectors provided with air and water passages. The air operating mode can be used for direct space heating, while the liquid operating mode would be more suitable for storage purposes.

The above national projects make use of the meteorological data of the "average Belgian year" which was assembled by the services of Koninklijk Meteorologisch Instituut - Institut Royal Météorologique of Belgium.

EEC-PROGRAMME

Both the K.U. Leuven and F.P.M. teams participate in the collector testing programme funded by the European Economic Communities and the national government. At the F.P.M. an E.E.C. funded study is being performed on the feasibility of using the heat of reaction of chemical reactions to store solar energy. A search for suitable reactions is being made considering the requirements of this specific solar application (storage capacity, decomposition temperature, stability, cost).

The K.U. Leuven-team participates in an EEC-project in which simulation models describing the performance of solar heating and hot water systems are compared between different research teams from EEC-countries. At the Katholieke Universiteit Leuven a pilot test facility, funded by the E.E.C. and the Belgian government, will be constructed in the near future. This facility consists of a reference system with 45 m^2 collector surface and a variable system of similar magnitude. With the pilot test facility it is possible to test full-size solar heating systems.

Under E.E.C. and Belgian government sponsorship, a hybrid photovoltaic-thermal solar system is studied at K.U. Leuven. This system makes use of collectors which concentrate the solar radiation upon an array of photovoltaic cells. The cooling of the cells provides a thermal energy output in addition to the electrical output of this hybrid system.

Finally, at K.U. Leuven the feasibility of solar-assisted heat pump systems for space heating in Belgium is studied under joint E.E.C.-Belgian government sponsorship. This study makes use of experimentally determined performance characteristics of heat pumps and solar components. These are used in a dynamic model describing the behaviour of various solar-assisted heat pump systems.

IEA PROGRAMME

The F.P.M. takes part in a comparative study of models describing the performance of solar heating and hot water systems. This work is coordinated by the International Energy Agency.

RESULTS

Results obtained from the above studies cannot be given yet since none of the projects has terminated as of this date.

CANADIAN SOLAR HEATING
RESEARCH AND DEVELOPMENT PROGRAM

J.R. Sasaki
National Research Council of Canada

INTRODUCTION

The aims of the Solar Heating Research and Development Program of the National Research Council are to:

- determine the feasibility of various ways of utilizing solar heating in Canada;
- develop simplified design methods and a data base for the rational design of solar heating systems;
- support construction of solar heating demonstration projects, to stimulate public interest and to obtain quantitative data on the performance of solar heating systems in Canada;
- assist Canadian equipment manufacturers to develop durable, cost-effective solar heating hardware.

The method chosen for pursuing the foregoing objectives has been to undertake some in-house activities within Federal government departments, and to issue research and development, demonstration and monitoring contracts. The level of effort has increased from zero in 1975-76 to $700,000 in 1976-77, $2,100,000 in 1977-78, and $5,650,000 in 1978-79.

A major change in the past year has been the establishment of a Solar Energy Projects Office within the NRC to administer the federal solar heating R & D program. The Head of the group is Mr. R.M. Aldwinckle. Dr. F.H. Krenz, the information and Liaison Officer within the group, will shortly be replacing Dr. D.G. Stephenson as the Canadian CCMS Contact Person.

The solar program in its early years has been directed more at developing information useful to all those involved in the development of a solar heating industry in Canada, rather than at direct support to potential manufacturers of solar heating components. This direction will begin to change in the near future.

The following is a review of the status of various elements of the program since September 1976.

FEASIBILITY STUDIES

A feasibility study on solar heating in Canada has been ongoing at the University of Waterloo under Professor K.G.T. Hollands since 1975. Two reports arising from this study have been sent to the CCMS contact persons since the last meeting. They are currently completing the final phase of this contract which is the development of a technique for ranking the thermal performance of solar collectors in terms of their use.

A feasibility study on the application of solar heating in buildings with complex mechanical heating and cooling systems, e.g., large commercial buildings, is being undertaken by the Federal Department of Public Works. A major consideration in this study is the selection of an appropriate computer program for simulating the behavior of mechanical heating systems with a solar collection subsystem.

SOLAR DATA BASE

The development of a solar data base is being undertaken by the Atmospheric Environment Service of the Department of Fisheries and Environment. Their intent is to prepare weather and solar radiation data for the major urban centres in a format that can be used by building heating engineers. To this end, they are developing a method for inferring insolation data for regions with no measured radiation data, and a reliable method for translating insolation data on horizontal surfaces into insolation data on inclined surfaces. This latter work is being conducted jointly with Professor J.E. Hay of the University of British Columbia.

DEMONSTRATIONS

The Demonstration Subprogram was designed to show the ability of solar heating systems to satisfy part of a building's heating load, and to provide an opportunity for monitoring the thermal and durability performance of different solar heating components and systems under Canadian climatic conditions.

Feasibility studies had indicated that solar service water heating was more practical than solar space heating; and that multi-unit residential buildings, and schools and hospitals were more appropriate applications of solar heating than single-family detached houses. Contrary to these indications, the 1976-77 program chose demonstration of active solar space heating systems in detached homes because it was felt that the solar heating systems for these buildings would be large enough to indicate the problems and performance of large collector arrays but were small enough to permit demonstration of a reasonable number of different systems across the country. Detached homes were also chosen because it was felt that the owners of such homes would be more receptive to energy-conserving methods, such as solar heating, than would apartment dwellers. Solar space heating systems were installed in 13 new and existing houses, and one other is now being installed. All utilize short term storage; seven use liquid-heating collectors and seven use air-heating collectors.

In 1977-78 support was provided for the installation of solar space and/or service water heating systems in 15 small multi-unit residential buildings, both new and existing. Three of the projects will have solar service water heating systems only; nine will have solar space and service water heating; and four will have solar space heating systems augmented by heat pumps. These projects are scheduled for completion this year.

In 1978-79, support will be provided for installing solar heating systems in non-residential buildings with a preference being given to those buildings with a significant service water heating demand.

MONITORING

The monitoring subprogram was aimed at determining the contribution of the solar system to the heating needs of buildings, as well as at determining the thermal and durability performance of the components. In 1976-77, two privately funded homes, one with a free-standing solar furnace and one with a passive solar wall, were monitored. The results were non-conclusive because of inadequate monitoring instrumentation. Two solar houses, the Provident House and the Mississauga House, were also monitored and continue to be monitored. Monitoring systems using integrating meters were installed in 12 of the funded single-family homes, but to date little information has been derived from these projects due to malfunction of both the solar systems and the monitoring instruments.

In the past year, a monitoring contract was let for a two-storey solar heated office building constructed by the New Brunswick Power Commission; and monitoring instrumentation design contracts were let for two solar heated schools and a solar heated Senior Citizens home, all constructed by the Ontario Government.

The intention is to monitor the performance of the 15 demonstration projects being constructed this year.

RESEARCH AND DEVELOPMENT

Over the past two years, this subprogram was intended to develop information that would be useful to both building system designers and potential manufacturers of solar heating systems and components. It was also intended to develop a Canadian capability for undertaking research and development on solar technology.

In 1976-77, studies were undertaken by contract on corrosion in solar systems, rock-bed storage, in-ground storage, development of air and liquid heating flat-plate collectors, and organic pigments for selective paints.

In 1977-78, 17 contracts were let for studies on control systems, durability of plastic covers, durability of concrete water storage tanks, chemical storage units, selective coatings and second generation collectors. A study on the physical condition of selected solar heating systems that have been in operation for some years in northern climatic regions was also instituted. Support to Canadian manufacturers of solar collectors was provided in the form of assistance to defray the cost of thermal evaluation testing.

FEDERAL GOVERNMENT ACTIVITIES

Other Federal government departments have been involved in solar heating activities, in addition to the activities of the Atmospheric Environment Service and the Department of Public Works already mentioned. Agriculture Canada has initiated feasibility studies and demonstrations of solar heating in agricultural applications. Central Mortgage and Housing Corporation continues with its study of the Solar Utility Concept, that is, the use of a large, central solar-collection and seasonal heat storage system serving the space heating needs of clusters of residential buildings.

The in-house activities of the NRC involve the following areas: development of appropriate test methods and standards for solar heating components; durability studies on solar heating components; and performance of large in-ground heat storage units. As part of the first activity, the NRC will be participating in the I.E.A. solar program on collector testing methods. The feasibility of indoor simulator testing is also being investigated. The NRC is also concerned with the establishment of adequate collector testing capabilities across Canada, and will be undertaking round-robin comparative tests with those having such a capability. In support of this area, assistance was provided for the establishment of an outdoor test facility at the Ontario Research Foundation. Preparation of a handbook describing construction features and costs of Canadian solar-heated buildings has also been undertaken.

One activity outside the solar R & D program being undertaken jointly by the NRC and the Housing and Urban Development Association of Canada (HUDAC), is the construction of four similar houses in Ottawa; one built to 1975 residential standards and the other three with additional energy-conservation features. All four houses will be electrically heated, but one will incorporate a supplementary solar air-heating system and another will have an air-to-air heat pump. The effectiveness of the energy-conserving features and of the solar-heating and heat-pump systems will be monitored in detail.

PROVINCIAL GOVERNMENT ACTIVITIES

In addition to the federal programs, several of the provinces have their own programs. The Ontario government has the largest of these which includes the construction of two schools, one with a solar service water heating system, and one with solar space and service water heating system augmented by a heat pump. A solar-heated Senior Citizen Home utilizing a seasonal water heat storage unit, and a cluster of 16 row housing units, 8 with solar space heating and 8 with solar service water heating, are also being constructed. They are also designing a number of institutional buildings such as court houses with solar as part of the heating system; and are introducing a program of support for manufacturers of solar components.

Prince Edward Island is introducing a number of solar service water heating systems on private single-family homes, and is planning the construction of a multi-unit residential building with solar heating. The solar-heated office building in New Brunswick has already been mentioned. Saskatchewan has sponsored the construction of a "zero-energy" home which has as one feature a solar collection system. Alberta is now developing plans for a demonstration and industrial support program.

PRIVATE SECTOR

With the exception of a number of private solar heated homes, there are very few examples of the private sector undertaking the introduction of solar heating systems in large housing developments or large non-residential buildings. Most large solar projects are being supported by some level of government, either federal, provincial or municipal. One notable exception is a shoe manufacturing company which has introduced a solar space heating system into one of its factories.

In manufacturing, there are 12 to 20 small companies manufacturing Canadian solar collectors. Several companies are also distributing imported collectors, mostly those from the Unites States.

SOLAR ENERGY R AND D PROJECTS IN DENMARK

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Technical University of Denmark

INTRODUCTION

The major portion of research activities relating to solar energy takes place at the Thermal Insulation Laboratory of the Technical University of Denmark and the Institute of Technology in Copenhagen. The research group at the Technical University consists at present of 12 full-time engineers under the direction of Professor V. Korsgaard.

The projects are financed by the Ministry of Energy, the Technical University, the Danish Council for Scientific and Industrial Research and the European Community (EC). Over a period of five years 20 mill Dcrs are available for solar heating R and D, and 7 mill Dcrs are available for a low-energy housing project.

During 1977 a Scandinavian section of the International Solar Energy Society was formed (chaired by Professor V. Korsgaard) with 200 members, 70 from Denmark.

RESEARCH PROJECTS IN PROGRESS AT THE TECHNICAL UNIVERSITY

The Zero Energy House (T.V. Esbensen, V. Korsgaard)

Measurements in the experimental house called the Zero Energy House have been undertaken since January 1976. From October 1976 to October 1977 the house was occupied by a typical Danish family of two adults and two school children. The measurements will continue until July 1978. It is the plan after this period to change the solar energy system primarily by introducing a heat pump.

The Low Energy House Project (V. Korsgaard, M.R. Byberg)

During the summer of 1978, six different adjacent low-energy houses will be constructed in Lyngby near Copenhagen. In this project, a low-energy house is defined as a one-family house, 120 m^2, with a total heat demand for space heating and hot water supply of not more than 5000 kWh per year. The total space heat demand is met, in part, by the free supply of heat from occupants and solar heat gain through windows. Additional space heat is supplied by electric lighting, solar energy systems, and heat pump systems. The auxiliary heat provided includes electricity for direct electric heating, the electric input to heat pumps, and the electric input to ventilators and pumps. The low-energy houses will be monitored and evaluated very carefully by the Technical University of Denmark for a period of two years.

Demonstration of Solar Heating Plants (H. Lawaetz, L. Sønderskov Jørgensen)

This project sponsored by the Ministry of Trade includes construction of eight solar heating plants, which will be measured carefully for a period of two years.

The eight demonstration plants include: A camping ground (50 m^2 collector area), a college (50 m^2), an existing single-family house (10 m^2), a new standard house (50 m^2), an existing one-family house (30 m^2), a hot water system for 12 dwellings (100 m^2), a solar assisted heat pump (90 m^2), and an existing apartment building.

The Outdoor Test Stand for Solar Collectors (C. Nielsen, P.E. Kristensen)

An outdoor test stand for testing the thermal efficiency of flat plate solar collectors has been constructed. Three solar collectors with liquid and two with air as transfer fluid can be tested at one time.

The Solar Simulator (S. Svendsen)

An indoor solar simulator for testing the efficiency of solar collectors has been constructed. The simulator is equipped with a 20 KW Xenon lamp illuminating an area of about 1.5 m x 2.0 m with an intensity of 1 kW/m^2.

Calculation of Radiation Data (H. Lund)

The objective of the project is to produce algorithms for calculation of hourly global radiation, direct normal radiation and diffuse sky radiation from normal meteorological observations of cloud cover and cloud types.

Projects in the International Energy Agency (J. Lemming)

IEA Solar Heating and Cooling Program, Sub-Project 1: Performance of solar heating, cooling and hot water supplying systems. The objective of the project is to establish and organize cooperation between the participating countries in the field of modelling and simulation of systems and in the field of measuring and reporting thermal performance of solar collectors. Denmark is the lead country for this task.

Passive Solar Heating Systems (L. Olsen)

A theoretical analysis of different passive solar heating systems and their influence on the indoor climate in the buildings. The analysis includes storage in concrete-slabs, waterfilled outer-walls and walls with latent heat materials.

Solar Energy Storage in the Ground (P. Nordskov Hansen)

An analysis of methods of transferring solar energy to the ground using the principles of evaporation, condensation and capillary tubing.

Solar Energy Storage in a Salt Hydrate (S. Furbo)

A new method adding extra water to the salt hydrate, so that all the salt can be dissolved in the water at the melting point, has been developed. If care is taken to stir gently, the salt dissolves completely in the water, when the salt hydrate melts. With this method no phase separation or decrease in storage capacity will occur, and the heat storage will work stably.

The other important problems are heat transfer and supercooling. These problems can be solved by using oil as heat transfer fluid. The oil is immiscible with the salt water mixture, and due to density differences the oil will form a layer at the top of the heat storage container and make good contact between transfer-and storage-media. The oildrops provide the gentle stirring, and this stirring prevents strong supercooling.

Test Facilities for Solar Heating Systems (C. Nielsen)

As part of the European Community Solar Energy Programs, 8 similar test facilities for solar heating systems will be established in the member countries this year. The objectives of the project are testing of full-scale solar heating systems and validation of system simulation programs.

OTHER SOLAR ENERGY ACTIVITIES IN DENMARK

Low Energy Houses in Skive

In 1977 the trade council in Skive organized a competition for the design of low-energy one-family houses. Twenty-three different project designs were received, 9 of which were selected for construction on adjacent lots in Skive.

All the residences have energy conservation features, and 8 of the 9 selected houses have solar energy systems for heating and hot water supply. Some of the solar systems are combined with heat pumps, and one house has a combination of solar and wind energy systems. The houses are instrumented and will be monitored by the Institute of Technology in Copenhagen.

Solar Heated Swimming Pool

A municipal swimming pool in Greve (south of Copenhagen) is heated by a solar energy system with a collector area of 480 m^2. The system is monitored.

A Solar-Powered Solid-Absorption Refrigeration System
(Refrigeration Laboratory, Technical University of Denmark)

Experimental investigation of the processes of absorption and generation of ammonia in calcium chloride was performed under conditions corresponding to those existing in a solar-powered refrigeration system. It has been shown that the necessary collector temperatures are within the working range of flat plate collectors. Various treatments of the absorbent, aimed at preventing migration of the salt after many cycles, were tested. A granular material consisting of calcium chloride with 15 percent Portland cement was selected as the most promising absorbent. A small demonstration plant has been built for testing at the University of Khartoum, Sudan.

INTERNATIONAL CO-OPERATION

The work in the solar heating research projects is conducted in close co-operation with research groups in other countries. The laboratory participates in the following international co-operative projects concerning solar heating of buildings:

CCMS Solar Energy Pilot Study

- System Reporting Format Committee
- Zero Energy House Experts Group (Chairman: Denmark)

EC (European Community)

- Research and Development Program in the Field of Solar Energy

International Energy Agency

- Investigation of the Performance of Solar Heating and Cooling Systems (Operating agent: Denmark)
- Co-ordination of Research and Development on Solar Heating and Cooling Components
- Performance Testing of Solar Collectors
- Use of Existing Meteorological Information for Solar Energy Applications
- Energy Conservation in Buildings and Community Systems.

FRENCH PROGRAMME FOR RESEARCH, DEVELOPMENT, AND DEMONSTRATION OF SOLAR HEATING AND COOLING IN BUILDINGS

M. Rodot
Centre National de la Recherche Scientifique

INTRODUCTION

This report updates the programme outlined at the previous meeting held at Copenhagen in September, 1976. As in 1976, the three main facets of the French national programme, which will be described below, are:

- Research programme of the Centre National de la Recherche Scientifique (CNRS) [National Center for Scientific Research].
- Research and experimentation programme of the Plan-Construction (PC) [Construction Plan] of the Ministry of Equipment.
- Demonstration programme of the Delegation aux Energies Nouvelles (DEN) [Commission on New Forms of Energy] of the Ministry of Industry.

CNRS RESEARCH PROGRAMME

CNRS is conducting a broad programme aimed at the use of solar energy in all its forms. Within this context, basic research is carried out for the practical development of solar heating and cooling systems for buildings. This research covers the following areas:

- Bioclimatic study of the notion of comfort
- Theoretic modelling, simulation, and experimentation of sub-systems (walls, collection/storage systems)
- Overall energy assessments of residential systems, including experimentation on solar heated and cooled houses
- Work involving flat plate collectors and thermal storage
- Studies of solar refrigeration.

These various projects are listed in Table 1.

PC RESEARCH AND EXPERIMENTATION PROGRAMME

The Plan Construction is undertaking a set of actions designed to improve housing. It includes a subprogramme on "Energy and Buildings", one of the dominant themes of which is energy conservation in buildings. In conjunction with this, the fourth Original Thermal Habitat (HOT) Competition in 1977 focused on large-scale experimentation with heat pumps, and in 1978 the sixth HOT competition devoted to thermal improvements of existing buildings, will get underway.

More specifically, the Plan Construction seeks to further scientific, technical, and architectural research leading to better utilization of solar techniques in buildings in temperate climates. A joint research project entitled "Climatology, Architecture, and Urban Design" was undertaken with the Bureau of Architecture on the following topics:

- Specific aids in the design of solar projects
- Climatic integration of buildings
- Microclimate of cities and urban structures and, as an application, the thermal rehabilitation of large complexes.

A second joint project on the same topic will begin in 1978 and, in addition, the fifth HOT competition, on the topic "architecture and climate", will focus on Mediterranean buildings.

Furthermore, research is being conducted on the topic of solar collection, controls and storage components in order to stimulate technical and technological progress. Experiments are being undertaken on the basis of projects selected during previous HOT competitions. The Plan Construction is also considering the socioeconomic and legal problems of energy in buildings. A list of PC projects is found in Table 2.

DEN DEMONSTRATION PROGRAMME

Demonstration programmes have been initiated by DEN and AEE (Agence aux Economies d'énergie) [Agency for Energy Conservation]. They concern the public and semi-public sectors and generally receive a 50 percent subsidy in order to cover the cost differential incurred by using solar energy rather than traditional heating techniques.

Two significant initiatives to promote solar heating in the residential sector also warrant mention:

- A F1,000 subsidy will be granted to any purchaser of a solar water heater
- An architectural competition has been launched by Société privée St.Gobain-Pont-à-Mousson .

Completed or ongoing experiments in France are listed in Table 3. The table describes solar space heating and domestic hot water projects in the residential, public, and industrial sectors by listing auxiliary energy and conserved energy, the type and surface area of collectors, the public agency subsidizing the project, and the date of entry into operation. Figure 1 is a map which gives the location of the projects in French territory.

In the nonresidential sector, swimming pools deserve special mention since the experience acquired to date shows that solar energy can be used very economically in this area. Throughout most of French territory it is possible to forego virtually any auxiliary fuel or electricity during most of the period of use.

The production of solar heated water in industry is also of interest. Several pilot projects in the agricultural sector can also be mentioned.

Solar air-conditioning and refrigeration techniques can also be illustrated by the future Maison du Bâtiment at Nice studied by the Comité Scientifique et Technique des Industries du Chauffage, de la Climatisation et du Conditionnement d'air (Costic) [Scientific and Technical Committee of the Heating and Air-Conditioning Industries], as well as by an experimental house being built at Antibes (Companie Francaise de Raffinage) [French Refining Company].

NEW COORDINATING COMMISSION

A Solar Energy Commission (Commissariat a l'Energie Solaire COMES) was established in March 1978 to programme and coordinate all the research, development, demonstration, and industrialization activities carried out by various French organizations on the solar energy applications.

TABLE 1: CNRS PROGRAMME

Bioclimatic Study of the Notion of Comfort

- Evaluation of thermal comfort/discomfort perceived in actual situations
- Measuring heat and humidity as comfort factors during sleep
- Role of internal temperature in the perception of thermal comfort

Subsystem Analysis

- Numberical calculation of transfer functions applicable to particular points on a building shell
- Thermally anisotropic composite structures
- Dynamic model of a collection/storage system with random input and output
- Greenhouse modelling and experimentation
- System analysis of greenhouses with thermocirculation
- Modelling, control, and optimization of solar heating systems

Overall Energy Assessment of Residential Systems

- Urban configuration and energy assessment of buildings
- Simulation of the thermal behavior of a building
- System analysis of the Mediterranean solar house
- Dwellings having an insulating wall facing south
- Solar building at Bourgoin-Jallieu

Components of Solar Buildings

- Optical study and characterization of various selective solar collectors
- Natural convection and radiation in flat plate collectors at average temperature
- Natural convection in flat plate collectors
- Influence of corrugation on the optical properties of surfaces
- Thermal storage
- Latent heat storage
- Crystallization of a mineral salt injected into a heat-transport fluid
- Study of interseasonal thermal storage
- Numerical study of heat storage in the transient regime of a storage layer

Solar Refrigeration

- Radiative cooling by means of selective surfaces
- Cooling by water evaporation in a natural air circulation
- Solid absorbents for refrigeration
- Solar refrigeration using absorption on zeolites

TABLE 2: REVIEW OF PC RESEARCH PROJECTS

I. Completed Research Projects

- Architectural design, habitat, natural setting, and energy
- Simultaneous processing of separate data (sun, wind) and simulation in project design
- Regulation tests on passive systems
- Integration of the solar function in new buildings (Claux and Pesso)
- Bioclimatic approach to architecture
- Methods applicable to the engineering of solar heating for residents
- Study of possible use of solar energy to heat dwellings. Calculation of maximum amount of recuperable solar inputs
- Research on the establishment of a solar power plant to heat and air-condition a building complex
- Physical and functional analysis and simulation of a heating system employing solar energy and energy of conventional origin
- Urban microclimates and simulation of thermal comfort factors in open urban spaces
- City planning and sun
- Feasibility of low-temperature convectors

II. Ongoing Research

- Long-term groundwater storage of low-temperature heat for buildings
- Heat storage and surface phenomena
- Tool to aid in the architectural design of a solar heated and cooled building making rational use of energy
- Thermal storage connected with solar energy use
- Study of possible use of the energy potential of surface water and the potential of long-term thermal storage in groundwater
- Integrated solar energy recuperation convectors
- Semiconcentrating collectors
- Vertically segregated large-capacity water storage
- Storage with miltitubular exchange in the ground
- Long-term storage for heating 20 dwellings with auxiliary gas
- Study of heat convection in thin rectangular ducts
- Measurement methods for the study of transient heat transfer between a building and its environment
- Study of heat transfer in heat storage
- Study of heat transfer with evaporation and application to greenhouses
- Optimization of thermal storage associated with the use of solar energy

- Experimental approach to the modelling of an apartment building at Bourgoin-Jallieu
- Light and solar heat in a greenhouse having variable transparency
- Thermal simulation model for the exploratory study of building shells of any configuration
- Quantitative aids to the design and climatic integration of solar heated and cooled buildings
- Bioclimatic approach to the Mediterranean house

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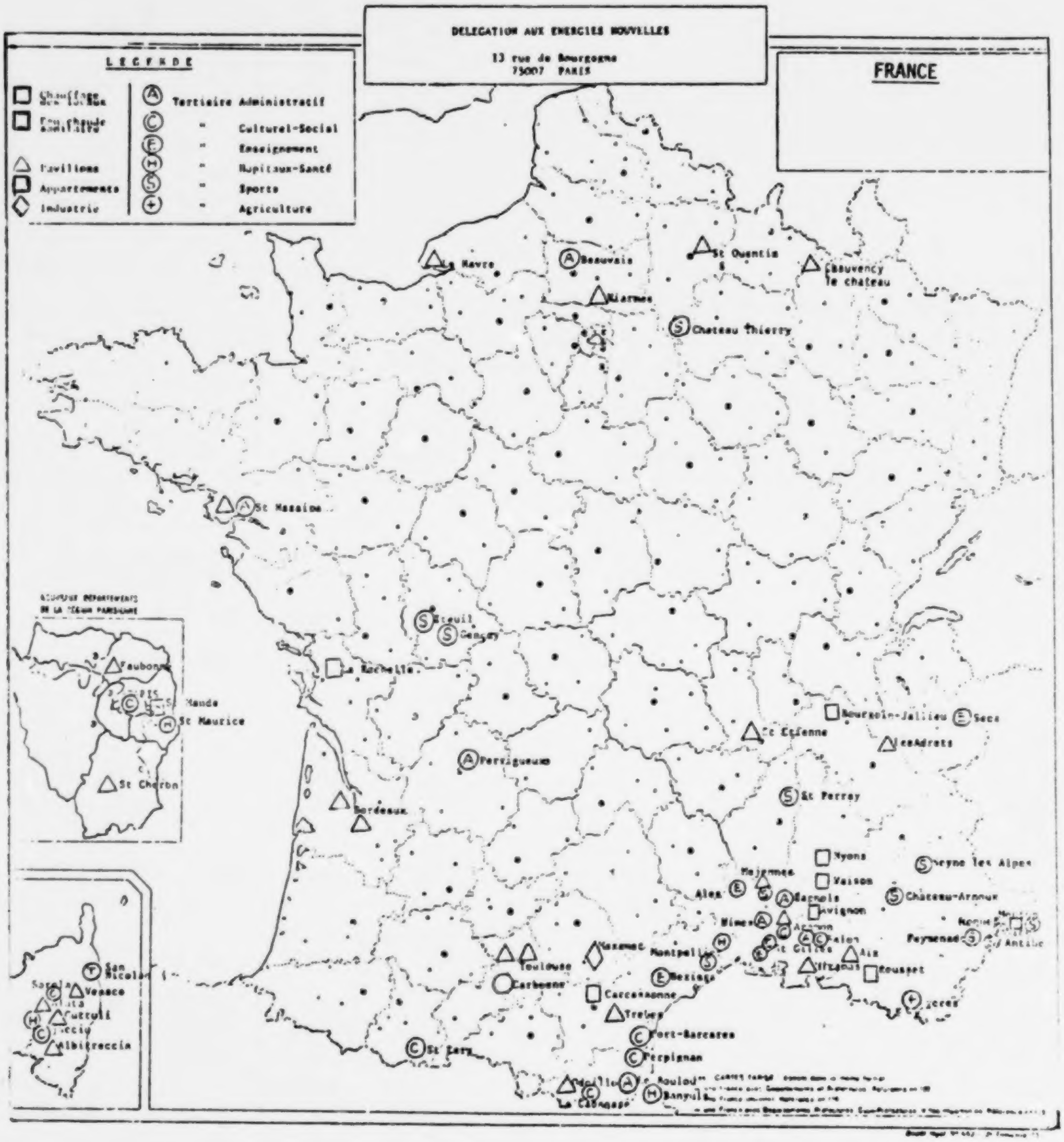

FIGURE 1
LOCATION OF MAJOR SOLAR DEMONSTRATION PROJECTS

DELEGATION AUX ENERGIES NOUVELLES
13 rue de Bourgogne
75007 PARIS
FRANCE
LEGENDE
Chauffage des locaux
Eau chaude sanitaire
Pavillons
Appartements
Industrie
Tertiaire Administratif
Culturel-Social
Enseignement
Hopitaux-Santé
Sports
Agriculture
Le Havre
Beauvais
St Quentin
Chauvency le chateau
Chateau Thierry
St Nazaire
La Rochelle
Perigueux
Bordeaux
St Etienne
Bourgoin-Jallieu
Sec
Les Adrets
St Perray
Nyons
Vaison
Alès
Avignon
Nimes
Montpellier
Château-Arnoux
Aix
Toulouse
Carbonne
Carcassonne
Beziers
Trebes
Port-Barcares
Perpignan
Banyuls
St Cloud
St Maurice
St Chéron
Vacavo
Cuttoli
Albitreccia

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Table 3

EXAMPLES OF MAJOR DEMONSTRATION PROJECTS (SEPTEMBER 1977)

Location	Department No.	Type of Project	Solar Application			Auxiliary Energy	Collector area (m^2)	Energy Conservation (tons, fuel or %)	Sponsor	Date of Entry into Operation
			Heating	DomHotWater	Other					
RESIDENTIAL PROJECTS		DETACHED HOUSES								
Aix-en-Provence	13	1 Pavillon Missenard	X	X		Elect.	35	1.7 TEP	—	Oct 1977
Aramon	30	8 Pavillons E D F	X	X		Elect.	318	17 TEP	—	Oct 1976
Blagnac	31	5 Pavillons HLM	X	X		Gaz	150 (2)	10 TEP	HOT	Sept 1976
		3 Pavillons HLM		X		Gaz	10.5			
Bordeaux	33	15 Pavillons HLM	X	X		Elect	— (2)	70 %	HOT	1979
Chauvency-le-Château	55	1 Pavillon	X	X		Elect.	45 (3)	—	—	1974
Le Havre	76	5 Pavillons	X	X		Elect.	124	10 TEP	—	1975
Odeillo	66	3 Pavillons CNRS	X	X		Elect	160 (3)		CNRS	1974
Saint-Quentin	02	3 Pavillons F 5 Missenard	X	X		Elect	145		—	1976
Trebes	12	3 Pavillons	X	X		Elect. (1)	90	3 TEP	HOT	Juin 1977
Toulouse	31	12 Pavillons	X	X		Gaz	144	10 TEP	HOT	1979
Viarmes	95	1 Pavillon Missenard	X	X		Elect.	55	30 %	—	1974
Saint-Etienne	42	14 Pavillons	X	X		—	1 250	100 %	HOT	—
RESIDENTIAL PROJECTS		APARTMENTS								
Avignon	84	48 Appartements (HLM) - La Bise -		X		Elect.	216	30 TEP	DEN	Oct 1977
Carcassonne	11	40 Appartements – Caserne Pompiers	X	X		Elect.	516	70 TEP	HOT	
La Rochelle	16	834 Appartements (HLM) ZUP de Villeneuve-les-Salins		X		Fuel	1 600	307 TEP	DEN	1977 1978
Marseille	13	4 Appartements (HLM)	X			Elect			HOT	Nov 1977
Nyons	26	61 Appartements (HLM)	X	X		Gaz	574	30 TEP	A E E	Oct 1977
Rousset	13	16 Appartements (HLM)	X	X		Elect.	269	22 TEP	HOT	1977
Saint-Mande	94	50 Appartements 101, av de Paris		X		Fuel	30	2 TEP	CSTB	Dec 1976
Vaison-la-Romaine	84	21 Appartements	X	X		Fuel	—	—	—	
Bourgoin-Jallieu	38	12 Appartements (HLM)	X	X		Elect.	305	15 TEP	CNRS CSTB	Janv 1978
PUBLIC BUILDINGS		ADMINISTRATIVE								
Bagnols-sur-Ceze	30	Gendarmerie	X	X		Elect	258	18 TEP	D E N	1978
Beauvais	60	Parfums Givenchy	X	X		Pompe chal	150	47 TEP	D E N	
Le Boulou	66	Auto-Port	X	X		Elect.	120	12 TEP	D E N	Nov 1976
Nice	06	Aeroport		X		Fuel	126	40 TEP	D E N	Jul 1976
Nimes	30	Direction Departementale de l Equipement	X	X		Fuel	44	21 TEP	D E N	1977
Salon-de-Provence	13	Hôtel des Impôts	X	X		Gaz	340	40 TEP	D E N	Janv 1977

(1) - pompe a chaleur pour 2 pavillons
(2) Capteurs a ruissellement
(3) Capteurs a air Trombe-Michel
EDF : Electricité de France
HLM : Habitations à Loyer Modéré

* HOT Plan Construction Habitat Original par la Thermique
CNRS Centre National de la Recherche Scientifique
DEN Delégation aux Energies Nouvelles
AEE Agence pour les Economies d'Energie
C.S.T.B. : Centre Scientifique et Technique du Bâtiment

Location	Department No.	Type of Project	Solar Application			Auxiliary Energy	Collector Area (m^2)	Energy Conservation (tons, fuel or %)	Sponsor	Date of Entry into Operation
			Heating	DomHotWater	Other					
PUBLIC BUILDINGS		EDUCATION								
Ales	30	Ecole des Mines	X	X		Gaz	1 215	40 TEP	D.E.N.	1977
Beziers	34	Centre de Formation Professionnelle des Adultes	X	X		Fuel	1 490 (3)	128 TEP	D.E.N.	1977
Carbonne	31	Ecole Maternelle et Primaire	X	X		Propa.	260	15 TEP	A.E.E.	Nov 1976
Séez	73	Ecole Materne	X			Fuel	200	5 TEP	D.E.N.	Janv 1977
Saint-Gilles	30	C.E.S. 900	X	X		Propa	472	50 TEP	D.E.N.	Sept 1977
PUBLIC BUILDINGS		SOCIOCULTURAL ESTABLISHMENT								
Ajaccio	20	Creche (60 berceaux)	X	X		Gaz	117	16 TEP	D.E.N.	Dec 1977
Aramon	30	Maison de Retraite		X		Elect	60	25 TEP	D.E.N.	Mai 1977
La Cabanasse	66	Maison de Vacances		X		Fuel	108	40 TEP	D.E.N.	Dec 1976
Paris	75	Cinema « Le Colisee »	X			Elect. + P. Ch.	100	68 TEP	D.E.N.	Oct 1976
Perpignan	66	Foyer des Personnes Agees		X		Elect	123	50 TEP	D.E.N.	Mar 1977
Port-Barcares	66	Village Vacances « L'Estanyot »		X		Elect.	78	52 TEP	D.E.N.	1978
Saint-Gilles	30	Maison de Retraite		X		Elect.	50	19 TEP	D.E.N.	Fin 1978
Saint-Lary	65	Aerium - Ministere de l'Interieur							D.E.N.	
Salon-de-Provence	13	Centre Social Marc-Sangnier		X		Gaz	66	6.5 TEP	D.E.N.	Juil 1976
PUBLIC BUILDINGS		SPORTS								
Antibes	06	Piscine municipale		X		Gaz	300	42 TEP	A.E.E.	Janv 1976
Château-Arnoux	04	Piscine couverte		X	X	Fuel	400	140 TEP	D.E.N.	Avril 1977
Château-Thierry	02	Piscine couverte		X	X	Gaz	420	30 TEP	D.E.N.	
Gençay	86	Centre Sportif		X		Elect	30	7.5 TEP	D.E.N.	
Iteuil	86	Centre Sportif		X	X	Fuel	60	10 TEP	D.E.N.	
Mejannes-le-Clap	30	Piscine exterieure		X	X	Fuel	150	14 TEP	D.E.N.	Juil 1976
Menton	06	Piscine couverte du Carei + Immeuble voisin d'habitation		X	X	Gaz	162	40 TEP	D.E.N.	
Montpellier	34	Piscine « La Paillade »		X	X	Gaz	350	44 TEP	D.E.N.	Juin 1977
Saint-Peray	07	Gymnase	X			Fuel	(3)	58 TEP	D.E.N.	Juil 1977
Seyne-les-Alpes	04	Piscine couverte		X	X	Fuel	100	8 TEP	D.E.N.	Juil 1976
PUBLIC BUILDINGS		COMMERCE								
		8 Stations service ELF		X				13 TEP	D.E.N.	1976
		2 Stations service ELF	X	X		Fuel			D.E.N.	
		HEALTH								
Banyuls	66	Centre He[illegible]-Marin		X	X	Fuel	108	35 TEP	D.E.N.	Dec 1976
Montpellier	34	Pavillon Hôpital Saint-Eloi		X		Fuel	1 000	125 TEP	D.E.N.	Fe. 1977
Saint-Maurice	94	Centre de Reeducation		X		Fuel	17	2 TEP	D.E.N.	
INDUSTRIAL AND AGRICULTURAL PROJECT		WOOL-COMBING MILL								
Mazamet	81	Usine de peignage de laine		X			100	27 TEP	D.E.N.	1976

LE PROGRAMME FRANCAIS DE RECHERCHE, DEVELOPPEMENT ET DEMONSTRATION SUR L'HABITAT SOLAIRE

M. Rodot
Centre National de la Recherche Scientifique

Ce texte constitue une mise à jour du programme décrit à la réunion précédente (Copenhagen, 13 septembre 1976).

Comme en 1976, les trois composantes principales du programme national francais, qui seront présentées ci-après, sont:

- le programme de recherches du Centre National de la Recherche Scientifique (C.N.R.S.).
- le programme de recherche et d'expérimentation du Plan-Construction (P.C.) du Ministère de l'Equipement.
- le programme de démonstration de la Délégation aux Energies Nouvelles (D.E.N.) au Ministère de l'Industrie.

PROGRAMME DE RECHERCHES DU C.N.R.S.

Le C.N.R.S. mène un large programme visant à l'utilisation de l'énergie solaire sous toutes ses formes. Dans ce cadre sont menées des recherches fondamentales nécessaires au développement pratique des systèmes d'habitat solaire. Ces recherches portent sur les points suivants:

- une étude bioclimatique de la notion de confort.
- des études de modélisation théorique, de simulation et d'expérimentation de sous-systèmes constitutifs de maisons (parois, systèmes de captation-stockage).
- des bilans énergétiques globaux de systèmes habités, y comprise l'expérimentation de maisons solaires.
- des travaux sur les collecteurs plans et sur le stockage thermique.
- des études sur la réfrigération solaire.

Ces divers travaux sont énumérés en annexe 1.

PROGRAMME DE RECHERCHE ET D'EXPÉRIMENTATION DU PLAN-CONSTRUCTION

Le Plan-Construction est un ensemble d'actions visant à l'amélioration de l'habitat. Il comporte un sous-programme "Energie et Habitat" dont un des thèmes dominants est celui des économies d'énergie dans l'habitat; c'est ainsi qu'a été lancé en 1977 la 4ème session du concours HOT (Habitat original par le thermique) centrée sur l'expérimentation à grande échelle des pompes à chaleur, et que sera lancée en 1978 la 6ème session du concours HOT consacrée à l'amélioration thermique de l'habitat existant.

Plus particulièrement, le Plan Construction vise à développer les recherches scientifiques, techniques et architecturales permettant à terme une meilleure utilisation des apports solaires dans l'habitat en climat tempé. Une consultation de recherche intitulée "Climatologie, architecture de l'habitat et formes urbaines" a été lancée conjointement avec la Direction de l'Architecture sur les thèmes suivants:

- l'évaluation du confort thermique domestique.
- les aides spécifiques à la conception de projets solaires.
- l'intégration climatique des édifices.
- la micro-climatique des villes et des formes urbaines et, comme application, la réhabilitation thermique des grands ensembles.

Une deuxième consultation sur le même thème sera lancé en 1978 et, de plus, la 5ème session du concours HOT sera lancée sur le thème "architecture et climats"; elle sera consacrée essentiellement à l'habitat méditerranéen.

Par ailleurs des recherches sont menées sur le thème des composan solaires de captation, de régulation et de stockage afin de stimuler le progrès technique et technologique.

Des réalisations expérimentales sont entreprises sur la base des projets retenus lors des concours HOT précédents.

Le Plan-Construction s'intéresse enfin aux problèmes socio-économiques et juridiques de l'énergie dans l'habitat.

PROGRAMME DE DÉMONSTRATION DE LA DÉLÉGATION AUX ENERGIES NOUVELLES

Des opérations de démonstration ont été lancées à l'initiative de la D.E.N. et de l' A.E.E. (Agence aux Economies d'énergie). Elles intéres sent les secteurs public et parapublic et sont subventionnées généralement à raison de 50% du surcroit d'investissement entrainé par l'utilisation de l'énergie solaire par rapport au chauffage traditionnel.

En outre doivent être mentionnées deux initiatives importantes visant à promouvoir le chauffage solaire dans le secteur résidentiel:

- d'une part l'octroi d'une subvention de 1.000 F à tout acquéreur de chauffe eau solaire a été décidé.

- d'autre part un concours a été lancé dans le milieu architecte par la Société privée St Gobain-Pont-à-Mousson.

Les expérimentations réalisées ou en cours de réalisation en France sont décrites par l' annexe 3. Les deux tableaux décrivent les opérations intéressant les secteurs résidentiel, tertiaire et industriel (chauffage et eau chaude solaire (E.C.S.)) en citant l'énergie d'appoint et l'énergie économisée, le type et la surface de capteurs, l'organisme public subventionnant éventuellement l'opération et la date de mise en service. La carte jointe situe ces opérations sur le territoire français.

Au sein du secteur non résidentiel, le cas des piscines mérite d'être souligné spécialement, l'expérience acquise dès maintenant montrant que l'utilisation de l'énergie solaire peut être dans ce cas particulièrement rentable. Il est possible, dans la majeure partie du territoire français, d'éviter pratiquement tout appoint de fuel et d'électricité pendant la plus grande partie de la saison d'utilisation.

Il convient de souligner également l'intéret de la production par énergie solaire d'eau chaude industrielle. Dans le secteur agricole également on peut signaler quelques expériences pilotes.

Les techniques de climatisation et de réfrigération par voie solaire peuvent être illustrées par le projet de la future Maison du Bâtiment de Nice étudié par le COSTIC (Comité Scientifique et Technique des Industries du Chauffage, de la Climatisation et du Conditionnement d'air), ainsi que par une maison expérimentale en cours d'achèvement à Antibes (Société: Compagnie Française de Raffinage).

REMARQUE COMPLÉMENTAIRE

Un Commissariat à l'Energie Solaire (COMES) a été créé en mars 1978 pour programmer et animer l'ensemble des activites de recherche développement, démonstration et industrialisation menées par les divers organismes français sur les applications de l'énergie solaire.

Le Président du COMES est M. Henry DURAND.

ANNEXE 1: PROGRAMME C. N. R. S.

Etude bioclimatique de la notion de confort

- Evaluation du confort inconfort thermique déclaré en situation réelle (MM. BARTH et GRIVEL, Strasbourg)

- Etalonnage d'indicateurs de confort thermo-hygrométrique au cours du sommeil (MM. VOGT et MUZET, Strasbourg).

- Role de la température interne sur la perception du confort thermique (MM. CABANAC et DUCLOS, Oullins).

Analyse de sours-systèmes

- Calcul numérique des fonctions de transfert relatives aux points singuliers de l'enveloppe d'un local (M. GERY, Lyon).
- Structures composites thermiquement anisotropes (M. MARTINET, Poitiers).
- Modèle dynamique d'un système captation-stockage avec entrée at sortie aléatoire (Melle BENARD, Orsay).
- Modélisation et expérimentation de serres (M. DAMAGNEZ, Avignon).
- Analyse-système de serres à thermocirculation (M. CALVET, Toulouse).
- Modélisation, commande et optimisation de systèmes de chauffage solaire (M. BERNHARD, Fontainebleau).

Bilans énergétiques globaux de systèmes habités

- Configuration urbaine et bilan énergétique de l'habitat (Mme MILLER-CHAGAS, Strasbourg).
- Simulation du comportement thermique d'un bâtiment (M. DABAT, Marseille).
- Analyse-système de la maison solaire méditerranéenne (M. SCHNEIDER, Nice).
- Habitations à insolateur mural en façade sud et à circulation d'air (M. Robert, Odeillo).
- Immeuble solaire de Bourgoin-Jallieu (M. KUHN, Grenoble).

Composants de l'habitat solaire

- Etude optique et caractérisation de divers revêtements sélectifs pour capteurs solaires (M. ABELES, Paris).
- Couplage convection naturelle-rayonnement dans un capteur plan à moyenne température (M. LAURIAT, Paris).
- La convection naturelle dans un convertisseur plan de l'énergie solaire (M. PERI, Marseille).
- Influence de rugosités sur les propriétés optiques de surfaces sélectives absorbantes (M. DELEUIL, Marseille).
- Accumulateurs thermiques (M. PEUBE, Poitiers).

- Stockage par chaleur latente (M. SCHNEIDER, Nice).
- Cristallisation en écoulement d'un sel minéral injecté dans un fluide caloporteur (M. PANTALONI, Marseille).
- Etude du stockage thermique intersaisonnier (M. CHOUNET, Orsay).
- Etude numérique de stockage de la chaleur en régime transitoire dans une nappe en charge (M. VACHAUD, Grenoble).

Réfrigération solaire

- Surfaces sélectives froides pour réfrigération par rayonnement (M. GRENIER, Meudon).
- Production de froid par évaporation d'eau dans une circulation naturelle d'air (M. PEUBE, Poitiers).
- Absorbants solides pour réfrigération (M. OLALDE, Odeillo).
- Réfrigération solaire par adsorption sur zéolites (M. MEUNIER, Orsay).

ANNEXE 2: LISTE RECAPITULATIVE DES RECHERCHES DU PLAN-CONSTRUCTION

I. RECHERCHES ACHEVEES

Financement 1974-1975

- AERIEN H (G. et J.M. ALEXANDROFF): conception architecturale, Habitat Milieu naturel et Energie.
- C.R.M.A.A. (Université de NANTES): traitement simultané de données de statut différent (soleil, vent) et simulation dans la conception des projets.
- E.N.S.A.I.S. (ADRERUS):
  - (I) Essais de régulation sur systèmes passifs (DENIS)
  - (II) Réflexions sur l'intégration de la fonction solaire dans l'habitat nouveau (CLAUX et PESSO)
- La FACE CACHEE DU SOLEIL (F. NICOLAS et M. VAYE): pour une approche bioclimatique de l'architecture.
- ESIM (Chambre de Commerce de MARSEILLE): méthodes applicables à l'ingénierie du chauffage solaire des habitats.

- CSTB: étude des possibilités d'utilisation de l'énergie solaire pour le chauffage des logements. Calcul de la valeur maximale des apports solaires récupérables.

- C. PRESENTE - P. ROULIER: recherche en vue de la création d'une centrale solaire pour le chauffage et le conditionnement d'un ensemble immobilier.

- BERTIN: analyse physique et fonctionnelle et simulation d'un système de chauffage concernant l'énergie solaire et l'énergie d'origine classique.

Financement 1976

- PENICAUD: micro-climats urbains, et simulation des éléments de confort thermique en espaces urbains ouverts.

- C.R.U.: Urbanisme et soleil.

Financement 1977

- BERTIN: Faisabilité de convecteurs à basse température.

II. RECHERCHES EN COURS

Financement 1976

- ARMINES - E.D.F.: stockage longue durée en nappes phréatiques des calories à basse température et utilisation pour l'habitat (achèvement 1978).

- Université de MONTPELLIER: Stockage de chaleur et phénomènes de surface (achèvement 1978)

Financement 1977

- INSA LYON: Outil d'aide à la conception architecturale d'un habitat solaire énergétiquement rationnel (achèvement début 1979).

- A.D.E.R. LEAT POITIERS: Stockage thermique associé à l'utilisation de l'énergie solaire (achèvement fin 78).

- B.R.G.M.: Etude des possibilités d'utilisation du potentiel énergétique de nappes superficielles et du potentiel de stockage thermique longue durée en nappes phréatiques (achèvement fin 78).

- C.E.R.C.A. P.U.K.: convecteurs à récupération d'énergie solaire intégrée (achèvement 1978).

- C.E.A.: capteurs à semi-concentration (achèvement 1978).

- OLIVET HAMAYON: stockage hydraulique de grande capacité à ségrégation verticale (achèvement 1978).

- GUIMBAL (S.G.E.T.): stockage avec échange multitubulaire dans le sol (achèvement 1978).

- GDF, CEA, LIEBARDT, ALEXANDROFF: stockage longue durée pour le chauffage d'une vingtaine de logements avec appoint gaz (achèvement fin 1978).

- M. MOUTON (Université de NANTES): étude de la convection de la chaleur dans les canaux rectangulaires de faible épaisseur (achèvement 1979).

- M. BARDON (Université de NANTES): méthodologie de mesure pour l'étude des transferts thermiques entre un bâtiment et son environnement en régime variable (achèvement 1978).

- M. BOISDET (CNRS ODEILLO): étude des transferts thermiques dans les accumulateurs de chaleur (achèvement 1978).

- Melle VACHON (CNRS ODEILLO): étude des transferts de chaleur avec évaporation-application aux serres (achèvement 1979).

- M. PEUBE (LEAT POITIERS): optimisation du stockage thermique associé a l'utilisation de l'énergie solaire (achèvement 1979).

- M. KUHN (Université de Grenoble): approche expérimentale d'une modélisation d'habitat collectif à BOURGOIN JALLIEU (achèvement 1979).

- MOSSER et ROBUEL: lumière et chaleur solaire dans une serre à transparence variable (achèvement 1978).

- COSTIC: modèle de simulation thermique pour l'étude exploratoire d'enveloppes de configuration quelconque (achèvement 1978).

- Mme MILLERCHAGAS (UPA STRASBOURG/ARIAS): configuration urbaine et bilan énergétique (achèvement 1979).

Financement 1978

- CALVET (CERT TOULOUSE) PELEGRIN et DIDIER, architectes: aides quantitatives à la conception et à l'intégration climatique d'habitats solaires (achèvement 1979).

- GROUPE ECOTHERMIQUE (SCHNEIDER, CNRS NICE) et PETITCOLLOT, architecte: approche bioclimatique de la maison méditerranéenne (achèvement 1979).

SOLAR ENERGY PROJECTS FOR HEATING OF BUILDINGS IN GERMANY

F.J. Friedrich
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INTRODUCTION

Research and development work devoted to the utilization of solar energy constitutes an important part of the Federal Government's overall concept of research into and development of new energy technologies. A comprehensive description can be found in the Solar Energy Technologies Programme 1977-1978 **. These activities are part of the Energy Research and Energy Technologies Programme 1977-1980, which is a continuation of the Non-Nuclear Energies Research Programme 1974-1977.

Germany's energy requirement is characterized by a very high percentage of thermal energy. Forty percent of the aggregate primary energy requirement is for space heating. The distribution of the ultimate energy requirement averaged over all sectors of consumption is (in round numbers):

- 40% space heat
- 36% process heat
- 24% light and power, three quarters of this percentage for transport.

The priorities established in research and development projects are based on this requirement distribution. For this reason, technologies for the efficient supply of low temperature heat (below 100° C) and the thermal utilization of solar energy are given funding priority. In the years 1974 to 1977 funds totaling approximately DM 50 million were allocated for the implementation of approximately 50 projects. Some of these projects have already been completed; a large number of new projects are still in the planning stage.

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* Management for Non-Nuclear Energy Research Programme

** Press Department, Federal Ministry for Research and Technology, D-5300 Bonn

Joint ventures within the framework of international cooperation supplement the research programme and enable a highly efficient utilization of available funds.

STATUS OF PROJECTS

Industry has been involved from the beginning of the programme, and today there are at least 100 firms manufacturing and selling solar hot water equipment, although there is no precise statistical material available on the number of residential systems in operation or under construction. It can be assumed, however, that several thousand systems of this type have been installed. An attempt to arrive at accurate figures is being undertaken by the German Solar Industries Association (BSE), which has sent questionnaires to 100 German manufacturers. The responses will be evaluated by an independent expert. This canvassing will be repeated semi-annually and provide information on the gradient of production and sales.

Current R&D-activities subsidized by the Federal Government can be summarized as follows:

Activity	No. of projects
System studies and measuring programmes	7
Low temperature thermal applications	
solar houses and demonstr. projects	6
complete systems	10
components	9
airheaters	2
Solar mechanical conversion	9
Photovoltaic conversion	7
Photochemical conversion	3

The focal point of the programme has been and still tends to be low temperature thermal applications. This topic will be described in more detail later on.

Increased activity has begun in the field of solar mechanical energy conversion for water pumping and electricity generation. Germany has joined the group of countries in the European Community and in the International Energy Agency financing power stations in the half megawatt and megawatt range. In the short and medium term, application of these technologies certainly lies beyond the European borders. Photovoltaic energy conversion has gained some importance in the last year and more money will be spent in this area in the future. Investigation into photochemical and photobiological conversion processes is being carried out on the university level; they are considered long range options.

R&D project trends and some essential developments are reviewed below. More detailed information on the projects can be obtained from the annual reports, "Energy R&D-Programme of the Federal Republic of Germany".*

System Studies and Measuring Programmes

Although the importance of system studies has been somewhat over emphasized in the past, they are nevertheless an important means for controlling and guiding the programme. In one of these studies the obstacles to the introduction of solar systems are being investigated. The various district governments in Germany have issued different building codes which in some cases complicate the installation of solar systems. Unless these obstacles are identified, they cannot be eliminated.

Accurate meteorological data are definitely an important prerequisite. The Nuclear Research Establishment at Jülich has developed a data collection system based on modern electronic technologies. The system is relatively cheap and will store data on cassette-tape or floppy-disc, which then can be transferred to a large computer system for evaluation.

Solar Houses

Hot water and space heating systems have attained a high technical standard of development and are being tested in experimental and pilot installations. Substantial progress has been made in understanding system behaviour (see Report of CCMS Zero Energy House Group elsewhere in these proceedings). Of the great number of solar buildings in this country, 16 have been equipped with data collecting and processing systems (Fig. 1 and Table 1). Several CCMS System Format Reports on the results have already been compiled and presented. All significant house projects are required to submit their reports in the Special Format.

Complete Systems

Complete systems here refers to solar system packages. Up to now it has been most advantageous to encourage the establishment of consortia representing firms of the various branches involved in building technology and collector manufacture and have them market solar systems jointly. These firms also offer the necessary system calculations in their computer facilities as a customer service. A plumber who can calculate and install conventional heating systems is certainly not in a position to optimize a system combining collectors, storage and control systems from different manufacturers.

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D-5170 Jülich

Components

The collector remains the key component of the solar system. There are many new developments, all based on the same principle. Four main development directions for hot water collectors are being followed:

- standard flat plate collectors

  with single and double glazing,

  with or without selective surfaces,

  (Aluminium and steel are used exclusively

  as absorber materials)
- flat plate heat pipe collectors
- tubular vacuum collectors
- concentrators

One major achievement in flat plate collector design is its integration into flat roofs. A skylight manufacturer has developed a neat design promising excellent long tern stability.

Concentrating collectors (cylinder paraboloids) have been developed for process heat applications. For solar cooling systems this solution promises to be a serious competitor for the high efficiency flat plate collector.

Air Heaters

Solar air heating systems have been developed for crop drying. Their application for space heating has been disregarded until now, since there are practically no air heated houses in this country. However this situation may change as a consequence of the work done by the CCMS Zero Energy House Group, which recommends elimination of air leakages in buildings and the introduction of controlled ventilation. Thus, the utilization of solar air heaters would be a logical step.

SUPPORTING ACTIONS

Research and Development

R&D efforts are still necessary in the following areas:

- System engineering. System simulation programmes have been worked out in detail. A broad validation of these computations is required and will be realized by a large scale system test comprising several hundred solar installations.
- Solar cooling has not yet received much attention in this country. It is well known that the lithium/bromide process can be utilized within certain limitations. A basic research programme has been started with the aim of finding new substances for absorption system working at lower input temperatures.
- Thermal energy storage seems to be a particular problem. Water and stones have been utilized satisfactorily. Many latent heat storage systems have been proposed but until now no single reliable and economical system is on the market. Additional research is definitely necessary in this field.
- Selective coatings of sufficient stability for aluminium absorbers are still not available. Research effort in this field will be intensified.
- Economical plastic collectors with sufficient life time represent a particular problem. For low-priced materials, the responsible manufacturer's warranty is still limited to a few years.
- Solar-assisted heat pump. A novel design for this well-known principle has been proposed. In this concept, only the absorber plate of a solar collector - without glazing and casing - is mounted on the roof, providing a large contact area to the ambient air. One firm proposes sandwiched steel elements as a substitute for roofing tiles. The system certainly cannot compete with a conventional solar collector on a very cold but clear winter day, but could have advantages in the mild and rainy winter climate of Northwestern Germany.

Fiscal Support

The following fiscal support actions have become effective:

- Income tax reduction (for private houses under construction)
- Income tax reduction (for private existing houses)
- Tax reduction for new solar-assisted heating systems which replace unserviceable old heating systems (all buildings)
- 7.5% investment benefit (synchronized with national investment programme)
- 30 million DM for installation in government-owned buildings (1978-1980)
- 4.35 billion DM investment programme for the installation of energy saving devices (improved wall insulation, double windows, heat pumps and solar systems).

Quality Standards

Quality standards for solar systems are considered necessary for consumer as well as for programme protection. Since the collector is the key component in a solar system, it is essential to know its properties prior to installation, e.g. its thermal characteristics and durability.

Standarized testing methods are being developed nationally and within the framework of the IEA. As a first step, a simple collector test rig has been developed which provides for relative measurements compared to a standard collector. There is unexpected interest from some developing countries and thus a small series of 10 units will be produced.

System safety is being considered by the DIN (German Industrial Standard) expert groups. They are formulating the regulations which will be introduced into the building code.

CONCLUSIONS

The German solar energy programme has expanded remarkably, and now encompasses a wide range of activities. However, the expected broad national market for solar systems is still several years away. The government is determined to bridge this gap by initiating various activities and programmes.

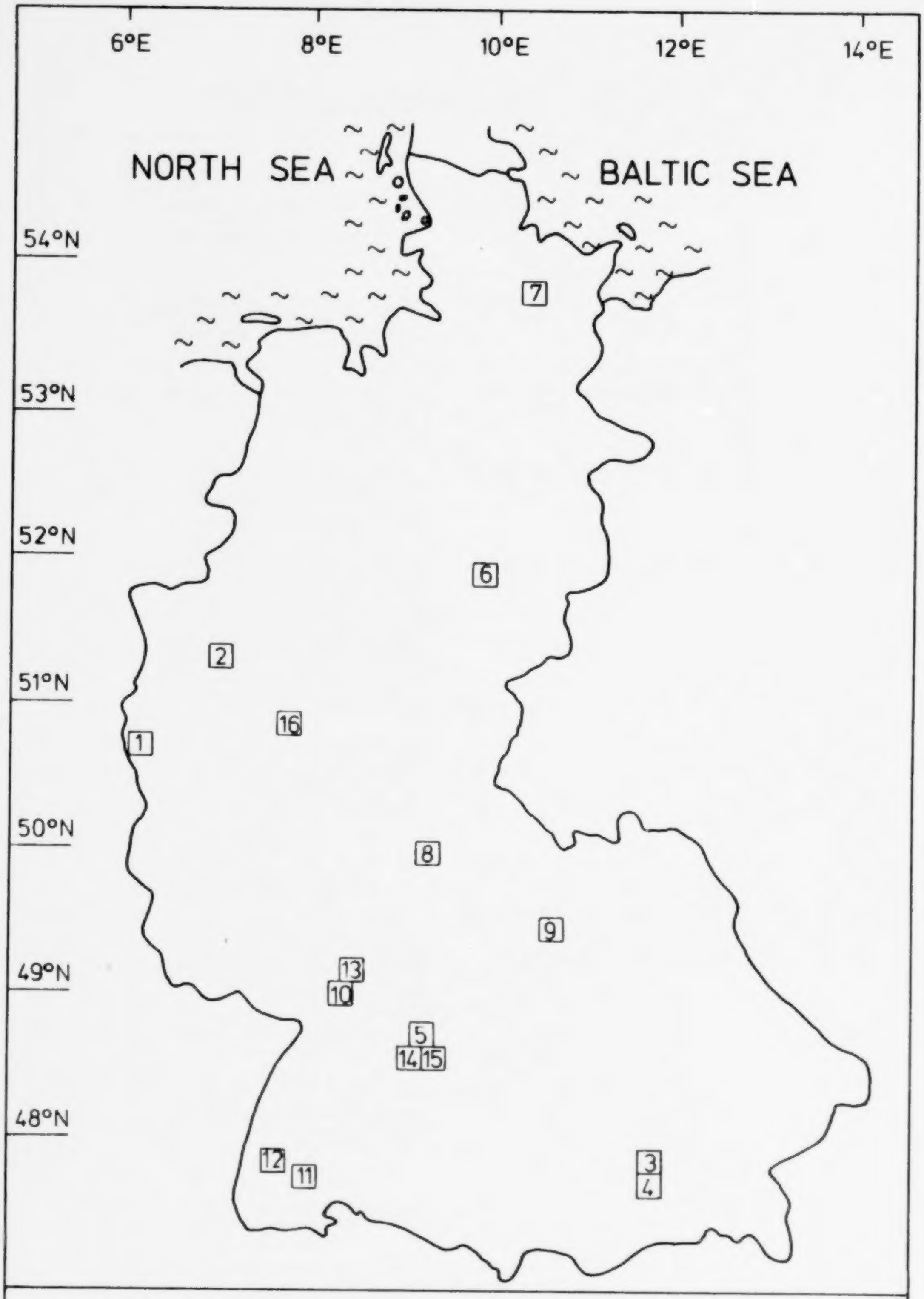
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Fig. 1 Solar Buildings with Data Evaluation in Germany
Sponsored by the Ministry for Research and Technology

TABLE 1: SOLAR BUILDINGS WITH DATA EVALUATION SYSTEMS IN GERMANY SPONSORED BY THE MINISTRY FOR RESEARCH AND TECHNOLOGY

No.	Location	Building	System
1	Aachen	One-family house (Habitation simulated)	Dom. hot water and space heating, 20 m^2 tubular evacuated coll.; 47 m^3 total water storage; Heat pumps; Heat recovery
2	Essen	One-family house	Swimming pool, dom. hot water and space heating; 69 m^2 heatpipe coll.; 7 m^3 total water storage; water-water heat pump
3	Höhenkirchen	One-family house	Dom. hot water and space heating; 35 m^2 flat plate coll.; 4 m^3 total water storage
4	Otterfing	One-family house	Swimming pool, dom. hot water and space heating; 80 m^2 flat plate coll.; 8 m^3 total water storage; 100 m^3 soil storage
5	Esslingen	One-family house and offices	Swimming pool, dom. hot water and space heating; 9 m^2 flat plate coll.; 3 m^3 total water storage
6	Salzhemmendorf	One-family house	Dom. hot water; 6 m^2 flat plate coll.; 0.4 m^3 total water storage
7	Wahlstedt	same as No.6 (Habit. sim.)	same as No. 6
8	Büdingen	same as No.7	same as No. 6
9	Elsendorf	same as No.7	same as No. 6
10	Walldorf	same as No.7	same as No. 6
11	Titisee	same as No.7	same as No. 6
12	Freiburg	10-apartment house	Dom. hot water and space heating; 60 m^2 tubular evacuated coll.; 23 m^3 total water storage
13	Bammental	Home for the aged (approx. 20 pers.)	Dom. hot water; 30 m^2 flat plate coll.; 1 m^3 total water storage
14	Heggbach	Home for invalids (approx. 450 persons)	Dom. hot water and space heating; 900 m^2 flat place coll.; 20 m^3 total water storage
15	Unterensingen	Gymnasium	Dom. hot water; 31 m^2 flat plate coll.; 9 m^3 total water storage
16	Wiehl	Public Outdoor Swimming Pool and Multi-Purpose Hall	Swimming pool, dom. hot water and space heating; 1600 m^2 flat plate coll.; 210 m^3 total water storage; heat pumps; heat recovery

SOLAR HEATING AND COOLING OF BUILDINGS IN ISRAEL

Harry Tabor
The Scientific Research Foundation

INTRODUCTION

While Israel has, relatively speaking, a rather wide solar energy program (taking into account the small size and limited financial resources of the country), only a small part of this is really directly related to Solar Heating and Cooling of Buildings. This is because the climate is relatively mild, the winter season is short and air conditioning for the summer is still a luxury for the majority of the people.

However, work on solar collectors components and control systems has relevance to Solar Heating and Cooling of Buildings and is therefore of interest.

GOVERNMENT SUPPORT

As indicated in earlier reports, the Israel Government has, in the solar energy field, supported two "national projects" (i.e. projects supported 80%) as well as a number of regular projects (50% support) and long-range exploratory research projects (100% support). The national projects are an attack on solar heating and cooling systems by a large commercial company, and work on solar ponds. The cooling work includes development of cooling machines of 50 tons or larger, as the company has, apparently, some doubts about the commercial viability of smaller systems. Maybe as experience grows, it will be possible to scale downwards to smaller units. Two other small projects deal with cooling; one is a passive system based upon nocturnal radiation.

SOLAR PONDS

The solar pond work is designed to build and test non-convecting solar ponds as a source of low-cost, low-grade solar heat (up to 90° C) for such purposes as heating and cooling of large buildings such as hotels. Thus one pond is being constructed at the Dead Sea area, where the major interest is in summer air-conditioning (for a hotel complex) rather than for heating. (The Dead Sea area, as a holiday and health resort, could be expanded considerably were it not for the shortage of electricity for air-conditioning: a local solar source could save the large infra-structure cost of new power lines from the centre of the country).

DOMESTIC HOT WATER HEATING

The increased use of solar water heaters, now estimated to have reached 250,000 domestic installations, has slowed down mainly because of the change in building patterns in recent years i.e. from single and duplex buildings to apartment blocks. The government has, therefore, sponsored a number of "communal" hot water installations i.e. where a central collector supplies many apartments. Some of these have been in conjunction with commercial companies, others in conjunction with the institutions of higher learning. The largest system (reported in earlier reports) was completed in May 1976 and has now had almost two years of operating experience. The 144 m^2 collector provides hot water to a hotel in Elat. The system was slightly oversized and, unfortunately, not adequately instrumented, but it is estimated to save about 95% of the annual fuel bill. Other central systems, of which there are about 60, include apartment houses, laboratories, students' hostels and offices. The systems are not all of one type: some involve central storage while others use individual tanks in each apartment, containing a heat-exchange coil fed from the solar collectors. In this case no central storage tank is needed: backup is by electric immersion elements under the (manual) control of the individual tenants.

SOLAR SPACE HEATING

One experiment on air heating of an office (part of the Ben Gurion University of the Negev) has been authorised recently. Prof. Givoni, of the same university, has received a donation permitting him to construct a house using some passive systems he has proposed.

One company has installed a few solar-assisted heat pumps i.e. where the collector raises the source temperature for the pump and avoids frosting. These are relatively small units of 4000 Kcals/hour capacity: they are also reversed in summer to provide conventional compressor cooling.

Closely related to application of solar heating and cooling is work on improved insulation and modeling of the thermal response of buildings.

In the field of collectors, there are a number of projects to improve selective surfaces, find new ways of constructing collectors to reduce cost, and some new configurations. Of a particular interest to Solar Heating and Cooling of Buildings is a project on designing a constructional roof element that also acts as a collector.

One small group is looking at phase-change materials for thermal energy storage.

AGRICULTURAL APPLICATIONS

In the agricultural field, there are several projects related to the thermal balance in greenhouses. The very clear skies in Israel result in very large swings of temperature between day and night. In one case an attempt is made to store the excess heat of the daylight hours and use it for heating at night. In another case, bag type collectors are being considered as a source of low-grade heat.

SOLAR ENERGY PROGRAM OF ITALY

Vincenzo Mazzaglia
Consiglio Nazionale delle Ricerche

INTRODUCTION

The principle research program in Solar Energy is being conducted under the energy program of the National Research Council (Consiglio Nazionale delle Ricerche). Aside from the CNR Solar Energy Project, other national activities are carried out by industry and corporations.

THE CNR PROGRAM

The objective of the CNR program is to make solar technologies efficient, reliable, competitive, and acceptable to their users. Solar energy prospects in three areas are being invesitgated:

- low temperature heating, cooling, and agricultural/industrial applications;
- high temperature applications using thermodynamic cycles for the production of electro-mechanical energy, and
- direct production of electricity using photovoltaic conversion.

These three research areas are further subdivided as follows:

A. Utilization of solar energy in the form of heat
   1. Thermodynamic properties and materials
   2. Planning and Control of Funding for Solar Installations
   3. Components and System Studies
   4. Cooling

B. Conversion of Solar Thermal Energy to Mechanical and Electrical Energy

C. Collection and Organization of Climatic Data

D. Photovoltaic Cells
   1. Photovoltaic Conversion: silicon development
   2. Photovoltaic Conversion: Other Semiconductors

E. System Demonstration

STATUS OF RESEARCH ACTIVITY PROPOSED FOR 1978

Utilization of Solar Energy in the Form of Heat

- Thermal properties of materials
    - gathering of lab and field data on the radiative and absorptive properties of materials for solar applications
    - identification of a polymer capable of thermal absorption in the transition from one solid state to another
    - compilation of selective coatings handbook containing properties, classification methods, use characteristics and production techniques
    - experimental simulation of collector heat loss coefficients.

The above projects were begun in 1977 and will continue in 1978. The following projects were added to the program in 1978:

- study of heat absorption materials
- improvement of insolation detectors
- direct and indrect measurement of emission properties
- development of selective surfaces.

Planning and Control of Funding for Solar Installations

Funds have been allocated for a number of buildings, including:

- the residential building at Fiume Veneto
- a solar school at Crosara di Marostica
- a custodial house for the Engineering Faculty of the University of Aquila
- a residence near the ENEL thermoelectric power plant at Rossano Calabro
- a solar school in Campiano.

These activities, initiated in 1977, will continue in 1978, along with the following new activities:

- study of solar buildings in various climates to determine energy efficiency in relation to climate
- study of efficiency of various flat-plat liquid-cooled collector types

- planned funding of solar installations on two day care centers in the city of Rome

- study of government funding procedures.

Components and System Studies

Activities begun in 1977 include:

- construction of prototype components for low- and medium-temperature (30-120°C) solar applications

- testing of component performance in solar installations

- development of a solar simulation program, aimed at evaluating the costs of solar hot water systems.

An inquiry into the state of the art of solar air collectors and heat pumps confirmed a general interest in the use of solar-assisted heat pumps coupled to low-temperature heating systems. Prototype rubber and plastic (Plexiglas) collectors have been constructed; tests of the rubber collectors have begun. Also, a moderately-concentrating collector is being developed.

Proposed activity for 1978 includes:

- development of a point-focus stationary concentrator

- study of passive solar systems for buildings

- study of new components (i.e., rubber and plastic collectors)

- simulation studies of energy demand and solar systems

- study of a solar desalination system

- study of research priorities.

Cooling

The solar cooling research program encompasses studies of the solar-powered absorption chiller with traditional and "open-cycle" systems. In addition, research will attempt to identify absorbent-refrigerant fluid pairs and develop small and medium size chillers. Activity began in the second half of 1977; a theoretical study is underway, comparing the advantages of absorption chillers to chillers based on other cooling cycles.

In 1978, activities will include:

- testing of sample systems

- study of chemical and physical properties of absorbent-refrigerant combinations for low temperatures

- study of a medium-temperature solar-powered desorber-generator.

Thermal Conversion of Solar Energy to Electrical and Mechanical Energy

Activities begun in 1977 include:

- reconstruction of the solar thermal power plant at Santa Ilerio di Nervi, with the addition of 150 new tracking mechanisms, 100 new heliostats, and the erection of the cooling tower
- testing of a thermal rotary motor.

Activities in 1978 will include:

- study of working fluids
- study of a 10-kW motor operated by medium-concentrating collectors
- study of a line-focus tracking collector
- study of a point-concentrating gas heater.

Solar Radiation Data Bases

Activities carried out in 1977 include:

- collection and refining of climatic data
- beginning operation of a new station at Vigna del Valle, near Rome.

Activities in 1978 will include eleven additional data-collection stations for the study of atmospheric absorption.

Photovoltaic Cells

The research, which began in July 1977, focuses on monocrystalline, polycrystalline, and amorphous silicon, as well as on cells using other materials.

- Photovoltaic Conversion: Silicon development
  - study to reduce manufacturing costs for solar cells
  - study of demand specifications for solar-grade silicon
  - development of a 1kW solar-electric plant using solar cells
- Photovoltaic Conversion: other semiconductors
  - research on gallium arsenide (Ga As) and cadmium sulfide (Cds)

- use of the laser to evaporate solids for producing thin films
- study of the problem of joining photovoltaic cells with external circuits.

Systems Demonstration

Six demonstration projects were proposed in 1977, including:

- a solar pilot plant for industrial application of solar energy on a large farm on Sardinia
- a solar module to provide an 80 kW-electric energy supply to a small population in an agricultural zone in Calabria
- an industrial process heat installation in Sicily
- development and installation of a solar-assisted heat pump in Campania.

OTHER NATIONAL ACTIVITIES

Other national activities are carried out by industries and corporations. The ENEL conducts a project for the European Community for the solar station under construction in Sicily (1 MWE). Feasibility studies on agricultural applications have been developed by Ente Nazionale Idrocarburica (ENI), together with cognitive research on energy consumption. Montedison is presently working on passive systems for buildings and is participating with other industries for the development of photovoltaics.

The Consiglio Nazionale delle Ricerche (CNR) participates in two International Energy Agency (IEA) solar implementing agreements: research on solar heating and cooling for buildings, and small solar thermal systems. The CNR also participates in the solar program of the European Community.

SOLAR PROGRAM OF LUXEMBOURG

J.L. Schleich
Ministry of Energy

Research on solar energy was initiated by Luxembourg industry in 1974. The government has been supporting industry since 1976 for research in areas of solar collector development and in solar-assisted heat pumps.

A demonstration domestic water heating project is being considered in Luxembourg.

The industry is participating in the solar testing program of Euratom, and has received research contracts from the E.C. Roof-integrated collectors for commercialisation are presently under study.

SOLAR ENERGY INDUSTRIAL ACTIVITY IN MONACO

J. H. Millar
FLEXTUBE S.A.

Principal work is being carried out at the Research and Test Centre in Tourrettes Sur Loup and at a factory in Monaco.

PERFORMANCE TESTING OF VARIOUS FLAT PLATE COLLECTORS

One type of test collector consisted of aluminium "Roll Bond" absorber plates painted black and enclosed in an envelope of Filon with no insulation. The remaining 30 panels were backed by 8 cm of fibre glass insulation. Of these panels, one had a sheet of aluminium honeycomb protected by one sheet of plain glass, a second one had one layer of Lexan and one of glass, a third had two layers of glass, a fourth had a sheet of Filon and a sheet of glass.

The highest temperatures - 60°C - were attained with the panel with two sheets of glass - with an input temperature of 35°C. Next was the panel with Filon - 55°C - and the Lexan panel the same. The panel with the aluminium honeycomb was below 50°C. All other 26 panels were double glazed. The average rate of flow through the panels was initially 2 litres/minute. When reduced to 1 litre/minute, substantial temperature increases were obtained, the highest being 85°C.

CONCENTRATING COLLECTOR DEVELOPMENT

Work is underway in design and testing of concentrating tracking collectors and design of evacuated tubes. For domestic hot water, heating of buildings, and industrial process heat below 250°C, the concentrating collector offers advantages when used in conjunction with a suitably insulated storage of the correct size and with a controlled flow, with properly designed heat exchangers.

Solar concentrators can take the form of parabolic tracking collectors such as those installed in the first demonstration unit, a factory in the Principality of Monaco (7°25 E, 43.44 N, altitude 25 metres).

In addition, there are non-imaging solar concentrators which do not move, in which the only moving parts are the pump rotor. Maintenance should be minimal. Cost will be proportional to the temperature and flow obtained. These non-imaging concentrators use mirrors to collect direct and diffuse radiation and concentrate them on a tube with a non-selective surface, through which flows a liquid to be heated. Re-radiation and heat loss from the tube is reduced by the vacuum between the tube and the outer tube of glass.

On bright sunny days a temperature of 300°C plus may be obtained. On "dull" days when the sun's rays are diffused, these non-imaging collectors can collect higher temperatures than are obtainable with the most efficient flat plate collectors under the same conditions, and sometimes even better than imaging tracking concentrating collectors. To improve efficiency by reducing heat losses, FLEXTUBE S.A. has designed vacuum tubes for both concentrating tracking collectors and for concentrating, non-imaging tracking collectors.

GREENHOUSE HEATING

From November to April, the 48m^2 of panels which from May to October heat the swimming pool, are available for greenhouse heating, using the same pump and flowmeter at reduced flow rate to circulate sun warmed water through radiators and pipes in the soil in the greenhouse. Alternative methods of greenhouse heating are still being explored.

ANTI-FREEZE AND CORROSION INHIBITORS

Since the panels were made of aluminium and used copper tubing, it was important to prevent corrosion destroying the panels. One project using a 30% corrosion resistant anti-freeze solution worked quite well. The anti-freeze solution used was THERMOCAL-B (Concentration 30% in 70% water) consisting of ethylene glycol plus corrosion inhibitors. The only immediate apparent disadvantage was that it stained the inside of the flowmeter tubes, making it difficult to see the position of the floats in the flowmeters. However, entrapped air was a problem and each morning at start-up a considerable amount of water had to be added - thus diluting the corrosion inhibitor and anti-freeze solution.

It is hoped that a new circuit arrangement, putting the air expansion chamber on top of the 30 litre tank and relocating the storage underneath the collectors themselves, will reduce, if not completely cure, the problem.

NEW ZEALAND'S SOLAR ENERGY PROGRAM

Department of Scientific and Industrial Research
Wellington

BACKGROUND

In 1957, the Department of Scientific and Industrial Research (DSIR) was instructed by the New Zealand Government to investigate solar technology as an alternative energy source. A preliminary survey showed that domestic solar water heating was the only likely candidate. This was because solar water heaters were advanced technically, and because nearly all New Zealand homes (800,000) had electrically heated storage hot water cylinders to which solar preheaters could be retrofitted with a minimum of cost and disturbance to the house structure. Space heating was not attractive because of the relatively small amount of energy used for this purpose, the considerable capital investment required, and the fact that space heating is inherently disadvantaged by having to supply the greatest amounts of heat at times of minimum sunshine.

From the onset it was clear that experimental evaluation was not practical because of the climatic differences between centres of population. Further, it was not yet known what constituted "optimised economic solar hardware." But the thermal characteristics of solar collectors had been well defined by this time and New Zealand was also well supplied with hourly records of air temperature and horizontal radiation dating back many years. This was sufficient material with which to start a computational study. A number of short term experiments were conducted from time to time to verify the modeling studies.

RESULTS OF EARLY MODELLING OF HOT WATER SYSTEMS

Modelling and experimental work on domestic hot water heating from 1957 to 1966 was summarized in a Technical Note issued by DSIR in 1965 (see Ref. 2).

The main summary features of this report were:

1. The potential performance of an acceptable form of solar water heater has been determined for 14 representative New Zealand towns ranging from Auckland to Invercargill. Various angles of tilt for the collectors are considered, also two water delivery temperatures (140° and 125°F).

2. Power savings for a unit intended for use in the average home are calculated for these same towns. (Using a collector of 45 square

feet) savings of at least 50% can be expected in most places. Savings in the worst site are only about 10% lower than those in the best.

3. The tilt of the collector is not critical and a relatively uniform yearly performance can be expected for angles between 15° and 40°. This means that collectors can be conveniently incorporated as part of the roof structure. Collectors should face nearly north, although small deviations are relatively unimportant. There is some evidence to suggest that a direction slightly west of north may be best in some areas.

In 1966 the work was terminated since it was clear that solar water heaters were uneconomic in competition with the cheap electric power then available.

MODELLING SOLAR RADIATION

An offshoot of the modelling studies was an investigation of solar radiation to see to what extent the simplistic assumption (that all radiation was direct) could be justified, and whether the model could be improved. The investigation was based on the paper by Liu and Jordan: The Interrelationship and Characteristic Distribution of Direct, Diffuse and Total Solar Radiation (3). An analysis was made of all available New Zealand solar radiation records to see to what extent they conformed with this data. The agreement was acceptable and a paper showing the results published (4). This paper also defined "standard solar years" for the five main recording centres in New Zealand, each year being made up of 12 "average months" with horizontal radiation and air temperature recorded hourly. Standard years are now held on computer files and used for all modelling studies, the total radiation on slope surfaces being computed as the sum of the direct, diffuse and reflected components.

TESTING SOLAR WATER HEATING SYSTEMS

In late 1971 DSIR moved back into solar energy research in anticipation of a growing demand for solar equipment in the future. With the modelling studies already complete, it was decided that the first requirement was for a solar collector designed for New Zealand industry and for the New Zealand climate (particularly frosts). This collector has now reached the New Zealand market.

However, a solar collector does not constitute a "system." The best collector can give miserable results if mismatched with the other components that complete the system -- solar storage tank, electrical booster tank, pumps, controls, etc. To evaluate the performance systems under real weather conditions, a testing facility was set up in 1972 to evaluate complete solar water heating systems. A minimum of three systems must be tested at any one time:

(a) One fully electric system without solar preheat

(b) One "reference system" comprising three square metres of conventional single glazed, black painted, copper collector connected in thermosiphon mode to the solar storage tank, and acting as a preheater for the electrically heated tank.

(c) The unit on test comprising approximately three square metres of collector and operating into its own particular arrangement of solar store, and again acting as a preheater to an electrically heated tank.

But from a commercial point of view, neither performance factors (nor, for that matter, collector efficiency tests) can answer the basic question of how much energy an installed system will save under realistic conditions of use. The question of savings can be studied in two ways:

(a) Field tests on systems installed and monitored in occupied homes.

(b) Controlled field trials where systems are exposed to real weather but where the demand for hot water is controlled and representative of "average household conditions."

Both methods are being used in New Zealand. Field tests in occupied houses are currently in operation, with the energy delivered by the solar preheater being measured by electronic integrators that accumulate the product of water flow and temperature difference whenever hot water is used in the home. Five units are installed and a further fifteen will be put in within the next year.

A complex for controlled field trials is in the building/planning stage following a Government directive to establish the potential performance of the many commercial solar water heaters that are currently available on the New Zealand market. The object of the tests is to provide reliable data that can be used by the consumer in comparing alternative products -- the "consumer" may be the private householder or government. The proposed test procedure (5) was written following a pilot project over a period of three months. Particular attention is given in the test to the very critical relationship between energy savings and the volume of water drawn through each system each day.

SPACE HEATING INVESTIGATIONS

Thus far, all New Zealand ventures into solar space heating have been carried out privately. Three solar heated houses were built about ten years ago (1 air/rockpile, 2 water/tank). All provide only partial heating and no performance figures have been made available. More recently a passive system (Trombe wall) has been built privately as part of a total energy house -- no data is yet available although instrumentation and monitoring is planned. There has been no Government sponsored research into single-house space heating for a very simple reason -- the economics are unfavourable. The average New Zealand home uses less than 5000 kWh annually for space heating, and 3800 kWh for water heating. Assuming a solar system might provide all the hot water and half the space heating, on present day energy costs this represents a saving of no more than $120 (NZ)/year for an expenditure of $10,000. This is not an attractive investment.

However, more than one-third of New Zealand's energy budget is committed to low temperature heating (space heating and water heating, both domestic and industrial) and this is clearly an area where solar heating can make a significant contribution. A considerable proportion of the high grade energy (electricity), derived from renewable resources (hydro and geothermal), is used for space heating and water heating. The obvious strategy is to substitute solar energy at the low end of the energy spectrum and free high grade energy for alternative use.

As a matter of policy, DSIR has decided to bypass the single-house solar concept and concentrate on large schemes where guaranteed supplies of heat and/or hot water are available at all times from solar operated equipment. If this can be achieved then there are savings in first cost because there is no longer a need for an alternative back-up system. This requires large-scale storage, on a seasonal basis.

A long-term storage system being currently investigated involves using a number of "nested" tanks instead of a single large tank with the object of "stratifying" the heat at graded temperatures so that collectors would always operate on the lowest temperature water in the system and thus attain maximum efficiency. Similarly, water for space heating would be drawn at the lowest temperature commensurate with the heat load at the time.

In cooperation with the Ministry of Works and Development, DSIR is planning the solar heating of a single building in this manner. While this is clearly a small-scale operation it will be treated as if it were a complete complex and is intended to serve as a pilot study of design, system control and performance. As many as nine storage tanks will be used in this exercise and current activity is concerned with monitoring the heating load of the building; testing the microprocessor that will control the system (in a laboratory-scale mock-up); and determining the thermal resistance between each tank, its neighbours, and the ambient. This last is a complex three-dimensional conduction problem which must be solved for accurate computer design of the system. Design is expected to take about one year, construction and commissioning one year, and initial charging a further year.

FARM DAIRY/HEATING SYSTEM

The National Dairy Laboratory of the Ministry of Agriculture and Fisheries has been studying the total energy picture on dairy farming in New Zealand. A constant supply of hot water is important in the milking shed for cleaning equipment and general hygiene. This group has been developing a pumped system utilising solar energy, but more recently have obtained good results from a thermosphon system.

UNIVERSITY RESEARCH

Notwithstanding the generally accepted thesis that there is no real place in New Zealand for the "conventional" single-dwelling solar heating system, the University of Auckland has been studying low energy housing with emphasis on architectural thermal control and solar space heating. This culminated in the design of a solar house in which two passive solar space heating systems were compared on the grounds that economic feasibility studies ruled against conventional systems. These studies continue and are providing useful material on the technical and economic difficulties involved in designing and operating solar space heating equipment (6). The University of Auckland is also studying photo-galvanic effects in anodic films as means of utilizing solar energy.

The University of Otago is conducting statistical studies of insolation, bright sunshine duration and cloud cover in Dunedin area.

Massey University is investigating solar water heating for farm dairies. A full size plant has been constructed and instrumentation and performance testing is being carried out.

ASSISTANCE TO INDUSTRY

The New Zealand Energy Research and Development Committee, a Government sponsored group who allocate finance under contract to non-Government agencies and industry, are currently sponsoring the development of cheaper domestic hot water solar systems. Two manufacturers are receiving assistance to develop complete systems (collectors, pumps, circulation equipment) with the aim of reducing the cost of the system to the householder. It is felt that involving manufacturers in the development of complete systems is an effective way of bringing costs down and is more acceptable to the householder who in the future will hopefully be encouraged to purchase a solar heating system for his domestic hot water supply.

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SOLAR HEATING AND COOLING ACTIVITIES IN SPAIN

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INTRODUCTION

Until 1977 solar energy activities in Spain were dispersed and lacking in coordination. Since then, the Centro de Estudios de la Energia (C.E.E.), within the Ministry of Industry and Energy, was created and given responsibility for coordination and financing of research and development projects on solar energy, both direct thermal applications and the production of electricity from solar energy.

Although a complete solar energy program has not been laid out yet, solar activities have significantly increased since last year with the involvement of the C.E.E., other laboratories and organizations, and private industry. Currently the C.E.E. is in the process of defining objectives with the aim of establishing a global program for 1979.

With regard to the field of space heating and cooling, Spain is perhaps in a somewhat particular situation. On one hand it is evident that with our climate we have good basis for applications on this field. However, for a number of reasons, the impact on the overall primary energy consumption would not be too significant. It has been established that currently in Spain only 7% of the primary energy is consumed for space heating and cooling and about 1% for domestic water heating. Another difficulty is related to our tendency towards high-density urbanization and high-rise residential buildings.

However, there is no doubt that for suburban areas and coastal zones where single family houses are common, space heating and cooling and water heating appear very attractive.

A significant impact is expected with the implementation of solar energy direct thermal systems to industrial applications for process heat and for water heating in public buildings such as hospitals, hotels, military quarters, etc.

GOVERNMENT ACTIVITIES

The Centro de Estudios de la Energia is currently engaged in a wide range analysis program of applications in industry (process heat, water heating, space heating) through a mailing of 30,000 survey cards. A computer program has been developed which analyzes the solar system and computes the system parameters. This program will permit an overall evaluation of solar energy on this field.

The C.E.E. is also considering a number of demonstration projects under contract. One of them, involving water heating for a hospital of 600 beds, has already been specified and will be awarded in June of the current year.

The Instituto Nacional de Tecnica Aeroespacial (I.N.T.A.) continues its activities in the tasks of the Solar Heating and Cooling Program of the International Energy Agency, working on testing of solar collectors, solar systems simulation and development of a solar assisted heat pump.

The Servicio Meteorologico Nacional, in cooperation with I.N.T.A. under contract with the C.E.E., is collecting data on solar radiation to be published at the end of 1978.

The Instituto de Optica of the Consejo Superior de Investigaciones Cientificas is currently developing mathematical methods for evaluation of solar radiation on tilted surfaces. In addition, an advanced test facility for complete solar systems is being constructed in which the overall performance of hot water, swimming pools and heating systems will be evaluated.

The state - holding Instituto Nacional de Industria (I.N.I.) initiated in 1978 a broad program for the development of solar technology, involving software activities, design and development of flat plate collectors and a cooperative program with MAN for the construction of a total energy plant of 50 KW electric power and 120,000 Kcal/hour thermal power.

PRIVATE ACTIVITIES

The activities of manufacturing and marketing of solar systems and components are experiencing a growing expansion, with more than 20 firms engaged in this trade. In May 15/21 Madrid will host the first Salon Monografico de la Energia Solar. The average size of the manufacturers is still small but the appearance in the market of large firms is imminent.

Solar water heaters are beginning to be common in single family houses along the Mediterranean coast.

An interesting example of privately promoted solar energy application is the Ederra Building in Madrid, Headquarters of Cristaleria Espanola, S.A., the largest glass manufacturer in Spain. This building combines advanced energy conservation measures with an active solar energy air system, consisting of 1,800 m^2 of vertical collectors in combination with a water storage tank of 500 m^3 and advanced heat pumps with a COP higher than 4. The back-up system of 100 KW was not required this last winter. With its large size, 18 floors high and 10,000 m^2 of floor area, this building is a good example of what can be achieved combining energy conservation and a solar energy system.

AN OUTLINE OF SWEDISH SOLAR ENERGY RESEARCH AND DEVELOPMENT IN THE BUILDING SECTOR

Lars Engström and Egil Öfverholm

INTRODUCTION

A national energy programme for the period 1978-81 will finally be passed in the fall of 1978. The main political struggle concerns nuclear power even within the present three-party government. On the other hand there is a rather unanimous agreement that energy conservation in new and existing buildings must be carried out. A recent government proposition suggests the investment of some 40 billion Sw. kr. (some 9 billion US) during the next ten year period with the aim of saving some 35 TWh/year net energy in today's stock of buildings. (The actual total gross energy consumption is in the vicinity of 500 TWh/year).

Solar energy for space heating also unites the political parties although those against nuclear power tend to emphasize alternative energy techniques such as biomass, wind power and solar energy conversion.

THE ENERGY R & D PLANNING AND GOVERNMENT PROPOSITION

Solar Heating in Buildings

During the winter of 1976-77 intense planning was carried out in the whole field of energy R & D. The Council for Building Research (BFR) formed a planning group for solar energy heating systems and storage. This group's recommendations were principally agreed to by the Council, although the suggested funds were cut with regard to the limited number of available competent researchers. The Council's programme proposal was in turn revised by the Delegation for Energy Research (DFE) and finally submitted to the Government. In the case of solar space heating, the Delegation closely followed the Council's proposals. The Government, however, in a recent proposition returned to the level originally suggested by the planning group.

The proposition directs 35 million Sw. kr for solar energy R & D for the period of 1978-81. To this will be added some 20 million Sw. kr for the planning and evaluation of experimental and demonstration projects (EXoD). The financing budget for the EXoD-programme will be 20 million Sw. kr a year, and this sum has already been allocated during fiscal year 1977-78. These funds are intended to cover plus-expenses for new techniques compared with conventional solutions. Total investment in experimental premises will thus be much greater, say some 100 million Sw. kr a year.

Solar Energy Production of Electric Power and Fuels

The R & D programme for solar energy production was prepared by a planning group formed under the National Board for Energy Source Development. Having investigated such possibilities as solar thermal power, photovoltaic solar energy conversion, photochemical production of electricity, hydrogen and hydrocarbon-fuels and low and medium-temperature processes for industrial purposes, the group recommended a programme of 28 million Sw. for 1978-81. The Board in its programme proposal to the Delegation presented an alternative proposal of 17 million Sw.kr,which also was passed on to the Government. The Government proposition groups solar energy with other techniques of long-term interest, so solar energy cannot be explicitly identified in terms of money. The Board, however, in cooperation with the original planning group, considers alternatives from a few up to 15 million Sw. kr for the whole planning period. Even the highest of these alternatives will only enable very modest projects.

SOLAR HEATING APPLICATIONS IN BUILDINGS

The goals of the R & D programme are:

- The collection of climatic data
- The development of solar collectors adapted to Swedish conditions
- The construction of storage units based on phase convertors
- The development of solar heating systems for swimming pools and of hot water heaters for showers
- The development of well-functioning domestic tap-water systems for use in existing multi-family dwellings
- The operation of large-scale space heating storage installations
- The construction of passive solar systems for demonstration purposes

Solar Space Heating

At present, relatively large solar heating plants supplying a number of buildings appear to be most favoured. One of the objectives of the research and demonstration activities during the planning period is the detailed design of 5 to 10 installations of this type and the construction of at least two.

Another objective is to erect individual solar heated buildings that will contribute to the building up of experience and knowledge at research institutes and in private companies. Opportunities will be provided for the detail of some 10-20 solar heated houses per annum. Of these approximately 10 will be selected and actually constructed during the entire period.

Priority will be given to development work on solutions for large buildings, multi-family dwellings, etc., as well as for existing buildings. In the latter case, only tap water heating seems promising. In many cases the evaluation of research and demonstration projects will be very demanding and must therefore be planned from the beginning in co-operation with a suitable group of researchers.

With regard to the research and demonstration part of the program it is proposed that activities consist of design and implementation. The design of a certain number of different projects will be wholly financed with government funds whereas support for their implementation will be available for one out of two.

Solar Heating of Swimming Pools

Solar heating of swimming pools and hot water heaters for showers connected to pools is already economically competitive. There is good reason to believe that development will continue once it has been started. The objective, therefore, is to initiate development by financial support for the design of a number of installations and some limited actual erections. Interested development groups have been invited to participate in this demonstration programme. Most of these installations will be located in northern Sweden.

During the first phase work will be concentrated on outdoor pools since these provide the most favourable opportunities for the utilization of solar heating. During a second phase a corresponding programme will be carried out for indoor pools. The objective is that both phases will be completed by 1981. The major part of the work will probably entail additions to existing installations.

Solar Tap-Water Heating

With regard to solar heating of tap water, experiments have shown that a water temperature of 45 C is sufficient for domestic purposes. This temperature is also favourable when utilizing solar heating and it is fully possible to supply existing buildings with water at this temperature without simultaneously incurring expensive alterations. The potential market is very large.

Both imported and domestically manufactured equipment is already available on the market for use in single-family homes. In order to obtain proper, statistically significant information about their operation (energy, savings, maintenance, economics, etc.) it will be necessary to follow at least 25 such installations per annum during the planning period.

However, government development funds are devoted to installation for multi-family dwellings or other large projects which, because of their larger capacity requirements and less favourable conditions for the erection of solar collectors, create certain difficulties with regard to the development of techniques and their marketing. A number of initial studies have now been completed and, using these as a basis, it ought to be possible to initiate design work on actual installations.

Invitations will be sent to interested development groups to participate in this part of the demonstration programme. The aim is to select project groups that will be provided with sufficient funds to carry out detailed design. Each year a few of these projects will be allocated funds for implementation. The programme is aimed at existing as well as new buildings, although emphasis will be placed on the former.

CONCLUSION

The final objective of the solar R&D activities is the development of an economic technique that enables a total replacement of the finite energy resources now used for the heating of buildings. It is apparent that basic research and development must continue and be intensified beyond the scope of the actual programme before this goal can be achieved.

The aim of the 1978-81 R&D programme is limited to the build-up of knowledge and experience over a very wide front both within research institutes and private companies. The research and demonstration activities will lead to a complete re-examination of theories and ideas and make it possible to evaluate techniques and function under realistic conditions.

SOLAR ENERGY PROGRAMME OF TURKEY

Department of Energy
Ministry of Energy and Natural Resources

INTRODUCTION

Turkey, lying between the 36th and 42nd parallels, is privileged with an outstanding solar energy potential due to the attractive geographic climatology of the country. Average yearly solar energy potential which could be assessed as low-temperature heat is estimated at about 36 x 10^6 tons of hard-coal equivalent. As a consequence of the solarimetry data compiled by the State Meteorological Organization, it can be concluded that the distribution of solar radiation intensity over the country is highly appropriate for all kinds of applications.

In response to the harnessing of this considerable potential, a formal solar energy program as part of the National Energy Plan has been formulated by the Ministry of Energy and Natural Resources. The short-term development programme is comprised solely of low-temperature applications. The most immediate activities would be for solar water and space heating of buildings, solar drying of agricultural products, heating of greenhouses, solar distillation and energy storing. In the long-term, sophisticated applications requiring more advanced technological development such as solar ponds, solar furnaces, solar thermal electricity generation, photo-voltaic, photo-chemical and thermo-chemical conversions will be investigated.

The relevant working programme is being executed under the administration and sponsorship of the Mineral Exploration and Research Institute (MTA) while coordinative responsibility is given to the Ministry. Various universities and governmental research institutions have also been involved in solar energy research, and considerable progress has been attained in recent years.

Nevertheless, the major portion of the research activities are now undertaken at the new "Marmaris Solar Energy Research Center" which was set up in the south-coast of Turkey, where the climate is highly appropriate for carrying out research activities in almost every month of the year.

MARMARIS SOLAR ENERGY RESEARCH CENTER

The general objective of the research center is investigation of a wide range of solar applications appropriate to the national objectives. Research activities essentially began in the early Summer of 1977 along with the establishment of the campus. Among the various R&D activities being carried out in low-temperature applications, the highest priority is assigned to solar heating and cooling of buildings.

In this regard, a national solar heating and cooling project was formulated by the Ministry of Energy and Natural Resources and is being executed under the administration of the MTA. The project has been organized in four phases, with major efforts devoted to solar heating and cooling of the four types of houses appropriate to the current conditions of Turkey:

- Village houses with no running water or electricity (heating only)
- Village houses with electricity but no running water (heating only)
- Small buildings with both running water and electricity (heating and cooling)
- Apartment buildings (heating and cooling)

The overall strategy of the project, initiated in June 1977, is first, to determine the feasibility of employing solar energy for heating buildings and secondly, to develop and test the reliability of the heating system which best fits Turkey's economic restrictions.

First Phase

The first phase of the project aims at developing a passive solar heating system (the Trombe-Michel) for those houses with no water or electricity. The building chosen for this step is a prefabricated house whose vertical, south-facing brick wall is converted into a solar heat trap by placement of a normal 3 cm glass cover in the front. The house is designed as a single room of 54 m^2 total heating area. The floor is concrete while the other elements have been prefabricated. Each panel contains 5 cm glass-wool between two wooden structures. There are no divisions inside so that the 7.35 x 2.60 m solar wall supplies heat to the whole volume. The system began operating in September 1977 and is expected to function through the 1977-78 winter.

A schematic diagram of the solar house is shown in Figure 1. The major operating mode is natural thermo-circulation. As can be identified from the figure, the house gains energy by thermo-circulation of air (Qt), by convection (Qt) and by radiation (Qr). The relevant expressions for these quantities are given below:

$$Q_t = V\rho \; Cp \; (To-Ti)$$

$$Q_c = h \; (Tm-Ta)$$

$$Q_r = \sum_{n=2}^{6} \frac{En,m \; (Tm^4 - Tn^4)}{1/Em + 1/En - 1}$$

where V : amount of air circulating in one hour (m3/hr)

ρ : density of air (1.1656 kg/m3)

Cp : specific heat of air (0.2405 kcal/kg C°)

To : air temperature at the outlet (°C)

Ti : air temperature at the inlet (°C)

with $h = 1.25\ (Tm-Ta)^{0.26}$ kcal/m2-, hr-°C

where Tn : surface temperature of the solar wall (°C)

Ta : room ambient temperature (°C)

Tn : $(1 \leq n \leq 6)$ surface temperatures of the six walls (°C)

En : emissivities of the corresponding walls

These parameters are being measured in 30 minute intervals and compiled data is being processed by an Interdata 8/32 computer. Figure 2 shows the variation of the related energy gain for the day 26/10/1977. Figure 3, on the other hand, presents the change in solar wall temperature and indoor ambient temperature together with the change in solar radiation intensity during the same day.

A prefabricated reference house, identical to the solar one, has also been installed next to the solar house and related measurements are underway for determining the energy balance and the annual efficiency of the solar heating system. As a consequence of the data to be compiled through one year with regard to energy-balance measurements, the optimum criteria for the solar wall will be identified for determining the reliability of the solar system during the heating season (15 December - 15th March), under Mediterranean climatic conditions.

Preliminary observations and assessment of the compiled data reveal the fact that, in Marmaris Region, solar energy could provide the entire heating demand of the solar house, estimated to be 6.35 kW. Even during the coldest day of the winter, the indoor temperature of the solar house has been observed to be greater than the reference house by 1°C.

Upon completion of the first phase of the project, solar walls made of sundried bricks will also be investigated since they constitute the usual local material for construction of village houses in rural areas.

Second Phase

In the second phase of the project, a basic hot air system will be investigated consisting of air-cooled collectors, and pebble-bed storage. While the relevant solar heating system is in the design stage, the test building chosen for this step has already been constructed. It is a 190 m^2 single-storey house with an estimated heat demand of 19.2 kW.

The optimum collector type to be used in this phase of the research project will be identified as a consequence of the on-going experimerts on various collectors differing in size and type of absorbing plate material. The selected air-collectors will be installed in May, 1978 and the relevant solar heating system measurements and testing will commence the following winter.

Third Phase

In the third phase of the research project, flat plate and movable solar collectors will constitute part of the solar heating system. Besides water storage, other suitable methods such as pebble-beds and chemical substances will also be considered. The design studies will commence by November, 1978.

Fourth Phase

In the fourth phase, a collector-radiator-heat pump system using unglazed collectors as daytime collectors and nighttime radiators will be studied. The solar heating system will be put into operation by October, 1980.

The four-phase project will be completed during 1981, at which time the optimum design criteria for solar heating and cooling systems in a variety of residential units (village type, single-family, and apartment houses) under Mediterranean climatic contitions will have been identified.

In addition to the above mentioned solar heating and cooling project, other activities in progress at the research center are outlined below:

Solarimetry Studies

A meteorological station, at which all the relevant meteorological and heliometric data are being recorded, has been in operation on the campus since June, 1977. Total and direct solar rediation on a horizontal surface, vertical surface and at a surface with 45° slope are being recorded for mapping the insolation period and the solar radiation intensity of the location.

Solar Collectors

Design and manufacture of various kinds of solar collectors (flat plate, cylindrical and parabolic) utilizing air or water as transfer fluid, are undertaken at the mechanical workshop established on the campus. Related experiments on various collector designs and materials are intended to identify the optimum collector types to be used in the second and third phases of the research project.

In order to increase the total efficiency of the horizontal collectors, various selective surfaces prepared by means of electrolysis are being tested at the recently established selective-surface laboratory to determine the thermal and optical parameters. Preliminary results reveal the fact that temperatures of 100°CC can easily be obtained. The appropriate collectors will be utilized in the construction of a solar-distillation unit which will be implemented in the near future.

Solar Water Heating

Various solar water-heaters (natural or forced circulation) have been manufactured and tested. In order to determine the global loss factors of the relevant collectors, a calorimeter was designed and manufactured at the mechanical laboratory. As the next step, manufacturing at the industrial level will be considered.

Solar Drying

Work is underway on various types of solar dryers for the purpose of pepper drying. Three different kinds of air collectors have been installed and tested. A prototype will be constructed in the near future. The feasibility studies for industrial applications are planned to be completed by the end of Summer, 1978.

Heating of Greenhouses

In regard to heating of greenhouses, the related R&D programme calls for construction of three types of greenhouses made of glass or plastic. Flat-plate collectors will be installed at an appropriate postiion outside the units or integrated on the roofs. For the first application, a plastic-covered 30 m^2 liquid collector will be implemented.

Solar Distillation

Construction of a solar distillation unit is almost completed. The selective surfaces were manufactured and tested at the selective-surface laboratory.

R AND D PROJECTS WITHIN UNIVERSITIES AND RESEARCH INSTITUTES

Solar energy research is being conducted at several universities and research institutes in following areas:

The Turkish Scientific and Technical Research Council (Gebze Research Institute and the Building Research Institute)

Architectural aspects of solar energy for energy conservation in buildings, solar heating of buildings (architectural and thermal design), solarimetry studies, R&D on solar collectors and storage methods.

Ege University

Dehydration of wood, various fruits and vegetables, solar collectors (optimum positioning for maximum solar energy reception in different provinces), solar distillation of sea water, development of the solar map of Turkey (total daily, seasonal and annual solar radiation for the whole territory of Turkey).

Middle East Technical University

Solar cells, domestic hot water and space heating of buildings.

INTERNATIONAL COOPERATION

Cooperation with international solar energy associations is also effectively taken into consideration. Turkey, being a member of NATO-COMS and COMPLES, participates actively in the relevant international pilot studies in accordance with the objectives of its national solar energy R&D programme. We certainly believe that the "Marmaris Solar Energy Research Center" will also be beneficial for the member countries of the recently formed "Mediterranean Climate Applications Group", since the proposed working programme of that group is similar to activities underway or planned at the research center. In this respect, mutual co-operation or implementation of joint projects could be undertaken.

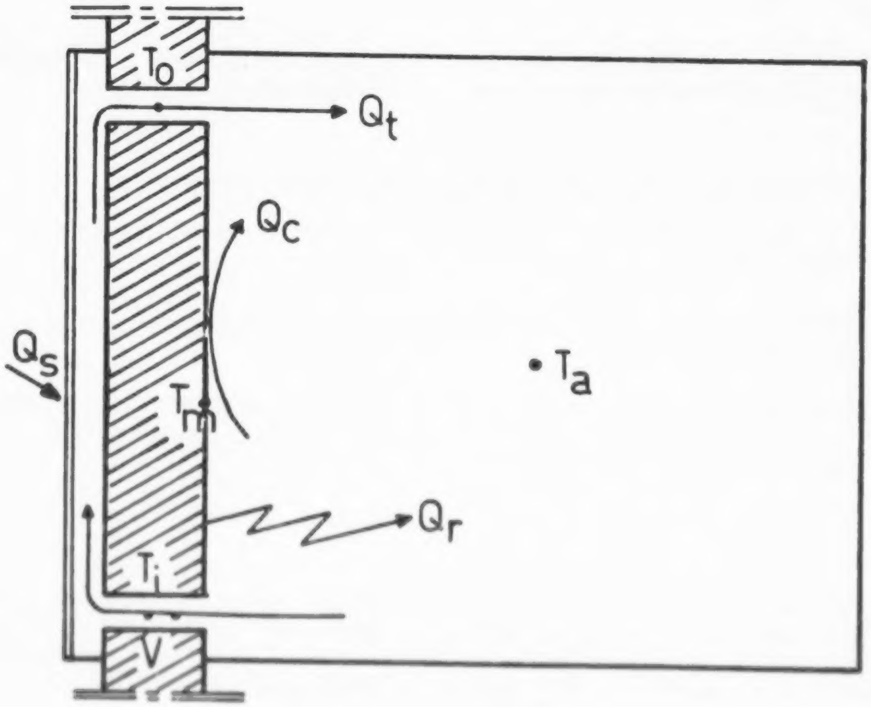
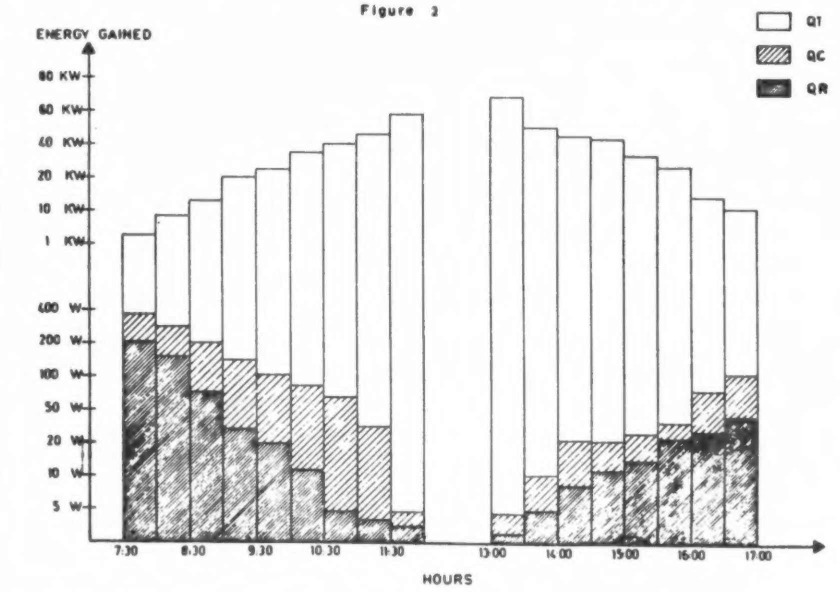
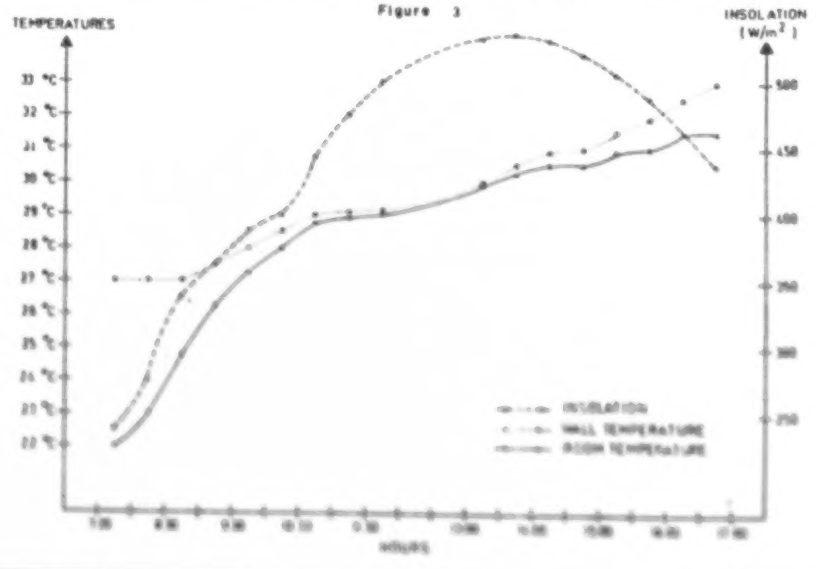


Fig. 1. A schematic diagram of the passively heated solar house.



VARIATION OF ENERGY GAIN FOR THE DAY 26/10/1977

Figure 2



CHANGE IN WALL AND IN DOOR AIR TEMPERATURES TO GETHER WITH THE CHANGE IN INSOLATION FOR THE DAY 26/10/1977

Figure 3

CURRENT RESEARCH ON SPACE AND WATER HEATING IN BUILDINGS IN THE UNITED KINGDOM

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INTRODUCTION

This paper aims to summarise the research and development currently in progress in the United Kingdom on the application of solar energy to space and water heating in buildings.

This catalogue cannot be complete for a number of reasons. First, it has been compiled from the information available to central government with the result that, although a full knowledge is thus available of all government funded projects, there is certainly work in progress which is being done independently and of which the government may not be aware. Second, even of the work which is being assisted financially within the government programme, some is commercially confidential. Third, the paper is concerned only with work which is conducted or reported in a research context. There are numerous firms making or supplying equipment or installing systems whose work is largely confined to the development required to produce a saleable product. Not only is central government not necessarily aware of all the systems being installed (exact figures are not available but the number runs into some thousands each year) but it has not even a complete register of the firms in the business.

OBJECTIVES

The broad objectives of the government programme are these: First, to obtain a clear indication of the potential future contribution of solar to meet national building energy requirements, for use in planning long-term energy supplies and in considering how loading patterns may affect distributed supplies of conventional energy. Second, to make the necessary information available for the protection of consumers (who have certainly been exposed to misleading advertising from some fims) and of the reputable companies who are equally the losers by the activities of suppliers offering equipment which cannot meet promised performance. Thirdly, to aid in the orderly development of the solar industry, an objective which matches well with the other two because it is not possible to have adequate confidence in the future performance of a technology which has not been brougt to a reasonable state of perfection, particularly in such a price-sensitive field as this.

The first objective is to be met by conducting or aiding research which will enable forecasts to be made of probable sales of equipment at various alternative prices of sytems and of competing fuels, together with a knowledge of how these systems will perform. The second aim will utilise corresponding sources of expertise to prepare British Standard codes of practice in this field. The first draft of a code is at an advanced stage and it is hoped to publish it during 1978, although there will certainly be revised editions in future years, towards which further research is now being put in hand. Our long-term hope is that international standards will be adopted which are widely applicable; although local characteristics of building practice will make some requirements national or regional in character, others (for example on performance testing) should have world-wide validity. Much work in this respect is being conducted by the European Communities, whose programme is being closely linked to that of the International Energy Agency by the Communities' Joint Research Centre at Ispra, Italy.

GOVERNMENT INVOLVEMENT

Britain has no research ministry, R & D being a function of the different Departments or Ministries. Those most concerned with solar heating for application in UK (and often also for export) are the Departments of Energy and of the Environment, the latter having responsibility for building, land use planning policy, and relations with local authorities, among other things. The greater part of the funding for the current programme is being provided by the Department of Energy which announced in February 1977 a programme of solar energy research to cost some six million pounds over four years, more than half of which would be devoted to space and water heating. In many cases this money will support industrial companies' research, often at a level of about 50 per cent, so the total value of the work will be considerably greater.

The Department of Industry's interest in solar energy is at present concerned mainly with prospective export markets, and it therefore provides almost all of the central government support to the development of equipment for the conversion of solar radiation to electricity. A major part of the national programme is of course being carried out in the universities, whose funding comes mainly (though not exclusively, for they have often private endowments) from three sources: (1) the University Grants Committee which handles Department of Education & Science support of the teaching function including payment of tenured academic staff, (2) the Science Research Council which supports graduate or post-doctoral students in projects submitted by their professors, and (3) firms or other departments of local or central government for whom work is done under contract, often on confidential terms.

Government policy is not aimed specifically at maximising the use of solar energy, on the grounds primarily that a given expenditure of public funds can at present hope to achieve greater economy in the use of conventional fuels if spent in other ways, for example improved insulation; but the government is alert to advocacy of specific fiscal or other measures to encourage solar installations.

CLIMATE

A brief note on the UK climate may be helpful. This is usually described as "temperate" with winter air temperatures seldom falling below -15 C and that only in exceptional winters; there are often long spells at around freezing point, with high relative humidity and cloudy skies. Clear winter days are not very common and ground level mean irradiance is correspondingly low. At London (52 N) the mean mid-winter horizontal surface radiation is not much more than one-tenth of that in mid-summer and most of what there is is diffuse. The ratio improves to about 1/7 for a 45 deg slope, but for horizontal surfaces it falls to around 7 per cent in the north of Scotland. Conditions are more favourable in Wales and South-West England, especially on the coast.

The space heating season is typically about seven months in the south and nine in the north, thus giving some opportunity to utilise the improved availability of solar energy in the spring and autumn. In the absence of interseasonal storage of solar heat, it would require a very large area of collector to make a sizable contribution to space heating loads although it is not necessarily out of the question to aim at possibly half the total space and water heating load for a very well insulated house. Generally, however, the present and closely foreseeable market is for water heating installations using 4 or 5 m^2 of flat plate collectors with the aim of meeting around 40 per cent of average annual water heating demands. These figures will of course vary widely with location, type of building, and pattern of use; and in the same way people have very different individual attitudes as to what constitutes an acceptable rate of return on capital investment. Thus the calculation that the return available to householders from solar installations is on average very low does not deny the existence of a real and already quite healthy market.

MAJOR PROJECTS

It would be possible to summarise between thirty and forty individual projects of interest but lack of space makes it possible only to comment briefly on some of the outstanding ones. Not all of these are funded by central government.

Early experiments (beyond what was already embodied in vernacular architectural practice) were concerned with "passive" utilisation of solar radiation. One house was built at Rickmansworth, Hertfordshire, by an architect for his own use in the early 1950's and its performance monitored and described. A more ambitious scheme was St George's School, Wallasey, Cheshire, built about 1960 and incorporating a south elevation wholly glazed, with a system of shades and reflecting louvres to control admission of solar energy and a wall construction providing diurnal storage. It was estimated that the adventitious gains from lighting and occupation would meet all other energy needs. This was largely achieved but at the expense of occasional excessive use of the lights, and of excessive noise transmission between classrooms due to a convective ventilation system which was not in itself altogether adequate. Nevertheless this pioneering venture will remain something of a milestone in the developing awareness of the scope for using solar energy in buildings.

Work on passive exploitation continues at the Electricity Council Research Centre which has been working on typical small houses with 90-100 sq m of floor area on two stories. Built to current regulation standards such a house may use annually 13 MWh of 'imported' useful heat and 3 MWh of solar heat; better insulation can reduce the net import requirement to about 4 MWh although solar gain is then slightly reduced. Higher national mandatory standards are under consideration.

An experimental application of the solar wall principle is being made at Higher Bebington, near Liverpool, where a group of new dwellings is being built primarily for retired people by a housing association. The services and monitoring are being done in collaboration with Pilkingtons and with the Institute for Advanced Architectural Studies in the University of York. The Department of Civil Engineering at the University of Leeds is also working, with EEC support, on theoretical and practical aspects of solar wall design.

The national building laboratory is the Building Research Establishment with its headquarters at Garston, Watford, established nearly sixty years ago. Work in the energy conservation programme includes the operation of solar water heating test rigs and experimental systems, commenced about three years ago. Computer models have been developed, and four experimental houses are nearing completion for observation of equipment performance under simulated occupancy. Two of these are concerned mainly with heat recovery and heat pumps. Of the others, one incorporates 20 m^2 of flat plate rooftop collectors with a 40 m^3 interseasonal store, using the sensible heat of water whose temperature can, if necessary, be allowed to fall to as little as 5 C, being up-graded by heat pumps for space and domestic water circuits. The fourth house has a steeply-pitched roof with E-W ridge; it incorporates a complex system of heat pumps which draw heat when appropriate from air entering the roof space after passing through a gap underlying the black south slope of the roof. Heat is also recovered from exhaust air.

The most experienced centre of research into most aspects of solar energy utilisation in buildings is University College, Cardiff, where work has been in progress for some eighteen years. Among many past and current projects is the construction of a solar simulator using lamps specially designed to present the nearest possible approximation to a correct solar spectrum, a property to which great importance is attached if the joint behaviour of an absorber plate and its glazed cover is to be correctly reproduced. One full-scale installation being monitored in detail is situated on a block of student apartments in the University, and uses 25 m^2 of collectors to provide hot water.

Several residential schemes have been promoted by local authorities, who, as owners of about one-third of the national housing stock, are better placed to monitor performance than experimenters on owner-occupied houses, unless these are themselves enthusiastic researchers. One active authority is the Development Corporation for Milton Keynes new town, some 70 km NW of London and also the location of the Open University which uses the BBC radio and television network for its teaching. The Corporation has at least four solar projects in various stages of construction, planning or negotiation; it has worked closely with its building contractors and with the Polytechnic of Central London and the

Open University's Energy Research Group. Its first solar house was completed two years ago and uses complementary gas and solar inputs for both space and water heating. Extensive monitoring has enabled many useful lessons to be learned from this project, now entering its third year with new tennants who may prove more typical than their predecessors whose energy use turned out to be only about half of what was expected. Nevertheless the year 1976/7 showed about 43 per cent of energy being provided by the 49 m^2 panels and with further refinements to the system it is hoped that this can be raised nearer to 60 per cent. Among the other schemes planned at Milton Keynes are one embodying low-energy passive principles with particular attention to orientation and fenestration; one which will monitor the effect of a number of conservation measures including window management; and others using active solar collection including a group scheme with a shared heat store. Other ventures in which the Polytechnic has been active are applications to agriculture, in one of which a low-cost water store is associated with raising the temperature of water at a fish farm.

Other local authority schemes have been promoted by the South London Consortium for Local Authority Building Research and Development. A typical example is a new six-person terraced house at Wandsworth which utilises a 5 m^2 panel area for water heating; other participants in the instrumentation and monitoring have included Ove Arup & Partners, Imperial College London and the Greater London Council.

A permanent exhibition and demonstration of equipment aiming to minimise the use of fuels in human settlements is to be seen at the National Centre for Alternative Technology, situated in a worked-out quarry at Pantperthog (Llwyngwern Quarry) near Machynlleth in Mid-Wales. One project at this centre is the provision of what is hoped to be the total heat requirement of an exhibition building by means of double glazed trickle collectors linked through an interseasonal water store to underfloor heating. The building uses the stone wall of a quarry workshop, massively insulated internally with polystyrene to give a "U" value of about 0.2, with a new roof incorporating 70 m^2 of collector on the south slope and another 30 m^2 at a slope of 55 deg against the south wall to improve winter collection. There are 200 m^2 of floor space at two levels with 110 m^2 at ground level heated to a surface temperature of around 21-25 C to give a winter air temperature of 15.5 C, enough for this particular building. To minimise capital cost, the storage tank uses a vee-shaped excavation lined with polystyrene and a butyl membrane to provide 100 m^3 of water volume, divided into two sections at different temperatures. The larger volume can reach 65 C while the smaller handles diurnal fluctuations and need not exceed 30 C.

Among work in industry, extensive studies have been made by the Shell Thornton Research Centre in Cheshire, including the modelling of system performance and the appraisal and development of materials and components including non-aqueous heat transfer fluids. Monitoring is in progress of a scheme designed and installed in a school at Sandbach, also in Cheshire, with 40 m^2 of panels supplementing an oil-fired space and water heating system. The Shell group has played a major part in the drafting of the new British Standard, together with the Groups at Cardiff, BRE, John Laing R & D, assisted by many others.

Napier College, Edinburgh, is working on several projects including studies of the effects of varying the thermal capacity of collectors on their performance and an investigation of the relative merits of using proportional and on-off controllers. The college is collaborating with Tube Investments Ltd on an experimental installation using 70 m^2 of collectors for water heating at a student hostel at Kirkcaldy, Fife.

GEC Power Engineering Ltd is applying the results of its studies to the design and subsequent monitoring of a pilot scheme for the provision of domestic hot water at a temperature not to exceed 43 C at a new unit for geriatric patients at the Glenfrith Community Hospital near the Company's Midland laboratory at Whetstone, Leicester. The initial installation will incorporate 250 m^2 of collector panels.

Satchwell Control Systems Ltd of Slough already market differential controllers for solar heating systems and they are now developing an extended range of products in this field. In addition to their own outdoor test rig they are monitoring the performance of installations in practical use, one of which is situated in a building on the Royal estate at Sandringham in Norfolk.

Among other research groups at work in Britain are the following; most of these have a number of projects in hand, but mention is made in some cases of those of particular interest:

The Agrement Board (outdoor test procedure based on Fourier analysis)

Brighton Polytechnic (non-tracking focussing collector)

Cambridge University: Depts of Engineering & Metallurgy; Whittle lab.

Department of the Environment: Property Services Agency (system installed at staff flats, British Embassy, Brasilia)

Distrimex Ltd (monitoring private house at Barnet, Herts)

Don Engineering (SW) Ltd (private house at Blyth, Notts)

Masini-Franklin Partnership (houses at Croydon)

Patscentre International (high efficiency flat plate collectors)

Plymouth Polytechnic (solar system with waste heat reclamation)

University of Sheffield (application of climatic data to design)

University of Strathclyde (monitoring solar/heat pump system)

Thor Cryogenics Ltd (development of water heating systems)

In conclusion, this paper should help to dispel any impression of a lack of activity in the United Kingdom in this important field. Although both the climate and current fuel price levels remain rather discouraging in the short term, the longer term prospects are now widely recognised.

REVIEW OF THE UNITED STATES SOLAR HEATING AND COOLING PROGRAM

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U. S. Department of Energy

INTRODUCTION

This paper presents an overview of the United States Solar Heating and Cooling Program. It is a summary of the information contained in several documents: National Program for Solar Heating and Cooling of Buildings - Annual Report (DOE/CS-0007); National Program Plan for Research and Development in Solar Heating and Cooling (DOE/CS-0008); Solar Heating and Cooling Demonstration Project Summaries (DOE/CS-0009); and Solar Heating and Cooling Research and Development Project Summaries (DOE/CS-0010); and Solar Agricultural and Industrial Process Heat Project Summaries (to be published in the Fall 1978). The overall goal of the Solar Heating and Cooling Program is to stimulate the advancement of an industrial, commercial and professional capability for producing and distributing various solar energy systems, thus reducing the demand on fossil fuel supplies through the widespread use in heating and cooling of residential and commercial buildings, for service and process hot water, and for the thermal needs of various agricultural and industrial processes.

The major elements of the Department of Energy's Solar Heating and Cooling Program are:

- Research and Development
- Residential and Commercial Demonstrations
- Agricultural and Industrial Applications
- Federal Buildings
- Technology Transfer
- Commercialization

Briefly, the objective of the R&D Program is to support the development of advanced components and systems with improved efficiency, lower costs and longer life. The Demonstration and Applications Programs will indicate ways to use available technology to meet the thermal requirements of buildings and of agricultural and industrial processes. The Federal Buildings Program is designed to encourage the use of available solar heating and cooling systems in Federal Government buildings, thereby providing a significant market demand. The Technology Transfer and Commercialization programs are new elements within the overall program. The Technology Transfer program seeks to stimulate market development forces of private industry and to transfer to industry those solar technologies with a potential for early impact applications. The Commercialization, or Market Development, Program will support activities to accelerate the commercialization processes for solar energy technologies in various market sectors. Another change in the basic structure of the DOE Heating and Cooling program has been the consolidation of Development in Support of Demonstrations activities into the Research and Development Program. The overall funding for the Solar Heating and Cooling Program for fiscal years 1977 and 1978 is shown in Table 1.

TABLE 1

SOLAR APPLICATIONS AND COMMERCIALIZATION FUNDING
($M)

	FY 77	FY 78
SOLAR APPLICATIONS		
• Demonstrations		
Buildings	62.0	64.4
Agriculture	2.4	2.8
Industrial Process Heat	6.1	7.5
• Systems Development	27.0	29.5
• Federal Programs		
Heating and Cooling Buildings	--	--
Photovoltaics	--	13.0
SOLAR COMMERCIALIZATION		
• Planning and Assessment	--	1.4
• Market Development and Training	4.4	2.6
CAPITAL EQUIPMENT	1.7	2.0
TOTAL	104.0	123.2

RESEARCH AND DEVELOPMENT

Program Objective

The objective of the current solar heating and cooling R&D program is to assist in creating a viable solar energy industry by supporting the development of improved, cost-competitive systems and components.

Structure of the R&D Program

The R&D program is based on the development of specific approaches -- paths -- to particular solar energy applications. A path links a method of energy collection or rejection with an application. Each path has a single objective: to develop the cost-effective technology to achieve the specific path application as quickly as possible.

Paths for the solar heating and cooling of buildings may sometimes lead to more than one application. Space heating paths, for example, generally involve hot water heating; space cooling generally involves both space and hot water heating. Agricultural and industrial process paths seldom relate to more than one application.

At the same time, there are many different paths leading to a given application of solar energy. Based on existing technology, some paths show more promise than others for developing economically competitive solar energy systems at the earliest possible time. Additional paths may be worth pursuing and, as a result of the R&D program, still other paths may become attractive. Nevertheless, to best meet its short-term objectives, the program plan details only 11 paths to the use of solar energy for the following building applications (Table 2):

TABLE 2

PATH DESCRIPTIONS FOR HEATING AND COOLING OF BUILDINGS

APPLICATIONS	PATH DESCRIPTION
Service Hot Water	• Liquid-Heating Collectors • Air-Heating Collectors
Space Heating	• Combined Solar and Heat Pump • Passive Heating of Space or Structure • Air-Heating Collectors • Liquid-Heating Collectors
Space Cooling	• High-Temperature Collectors with Absorption or Heat Engine/Vapor Compression Chillers • Medium-Temperature Collectors with Absorption, Heat Engine/Vapor Compression, and Other Chillers • Flat Plate/Advanced, Non-Concentrating Collectors with Desiccant Chiller/Dehumidifier • Passive and Hybrid Cooling • Combined Solar and Heat Pump

The plan also calls for 11 paths to the use of solar energy for agricultural and industrial process applications (Table 3).

TABLE 3

PATH DESCRIPTIONS FOR AGRICULTURAL AND INDUSTRIAL PROCESSES

APPLICATION	PATH DESCRIPTIONS
Shelter Heating	• Passive Heating • Air-Heating Collectors • Liquid-Heating Collectors
Drying	• Direct Drying • Air-Heating Collectors • Liquid-Heating Collectors
Process Hot Water	• Liquid-Heating Collectors • Air-Heating Collectors
Process Steam	• Liquid-Heating Collectors
Cooling and Refrigeration	• Passive Cooling • Active Cooling and Refrigeration

Some paths require an emphasis on materials development, some on system analysis, and others on component development and testing. To move along any of the paths, specific tasks must be undertaken, either in parallel or in series. Tasks have been identified, grouped in five functional categories, and arranged in sequence to allow the paths to develop in a logical order. The importance of each task to a given path is indicated in the R&D Plan (1).

Prior to the development of this directed R&D plan, the R&D program consisted of projects based on unsolicited proposals. With the distribution of the interim National Program Plan for Research and Development in Solar Heating and Cooling, (2), the procurements shifted to solicited proposals.

In FY 1977, a series of 11 Requests for Proposals (RFPs) and Program Research and Development Announcements (PRDAs) was issued by the Research and Development Branch of ERDA's Division of Solar Energy. These solicitations called for proposals specifically related to one or more tasks in the directed R&D plan. Out of the 1200 proposals received, approximately 140 projects were selected for support. The balanced involvement of industries, universities, small businesses, and government organizations, which characterized the prior research and development program, was continued by these awards. Several of the DOE laboratories and the new Solar Energy Research Institute (SERI) continue to provide technical review and program support.

Program Status

Emphasis within the present R&D program is upon cooling technology, cost-effectiveness and system design, as well as upon advanced systems development, passive systems, retrofit systems, and agriculture and industrial process heating systems.

Funding for the FY 1978 R&D Program is $18.5 million, an increase of $3.5 million over the previous fiscal year. The FY 1978 funds will be distributed among the major program elements as follows:

PROGRAM ELEMENT	FY 78 FUNDING ($M)
Collectors	7.0
Storage/Heat Exchange	2.2
Heat Pump	2.1
Cooling	1.0
Systems/Controls	3.7
Support	2.5

The relatively low funding of the solar cooling element of the R&D program simply reflects its relatively high funding during FY 1977. During the past year and a half since the last CCMS meeting, the solar R&D program expanded from 76 projects to 244 projects. Most of these projects are directed at providing improved performance in components, improved manufacturing techniques, and/or lower initial and maintenance costs. The projects in each of the program elements are described briefly below. More complete descriptions are contained in the Solar Heating and Cooling R&D Program Project Summaries (3), which will be sent to the Pilot Study Contact Persons.

Collectors -- 99 projects. Emphasis on development of air and liquid flat plate and tubular-evacuated collectors (26 projects), focusing and non-focusing concentrating collectors (19 projects), materials (41 projects) and analyses (13 projects).

Thermal Storage -- 25 projects. Emphasis on sensible (5 projects), phase-change (6 projects), chemical (1 project), exchangers (3 projects) and analyses (10 projects).

Heat Pumps -- 9 projects. Emphasis on system configuration analyses (5 projects) and advanced heat pump designs (4 projects).

Cooling -- 36 projects. Emphasis on absorption (4 projects), Rankine/vapor compression (9 projects), heat pump (9 projects), desiccant (6 projects), passive (1 project), photovoltaic (1 project), and system studies/analyses (6 projects).

Systems -- 70 projects. Emphasis on passive system development (30 projects), controls (17 projects), system simulation/validation (15 projects), economic analyses (5 projects), and retrofit system development (3 projects).

Significant Accomplishments

Some significant recent accomplishments in the R&D program are as follows:

- Active systems
    - developed prototype integrated 3-ton absorption chiller heating and cooling system with 195°F (90°C) design operating temperature;
    - developed integrated "Solaire" heating system for retrofit applications;
    - developed widely used computer programs for solar system performance and economic modeling.
- Passive Systems
    - drafted passive solar design guidelines and handbook;
    - instrumented and monitored 29 passive buildings and 15 test cells of various designs.
- Components
    - commercialized non-tracking compound parabolic concentrating collector by several manufacturers;
    - commercialized faceted mirror tracking concentrator.

DEMONSTRATION PROGRAMS

The objective of the Department of Energy Solar Heating and Cooling Demonstration Program is to increase public confidence in solar heating and cooling systems in commercial and residential buildings, using available systems installed in both new and existing buildings. The program also provides for collection, evaluation and dissemination of data and the development of standards and performance criteria for these systems.

The current Department of Energy Solar Heating and Cooling Demonstration Program encompasses four areas:

- Residential Demonstrations
- Commercial Demonstrations

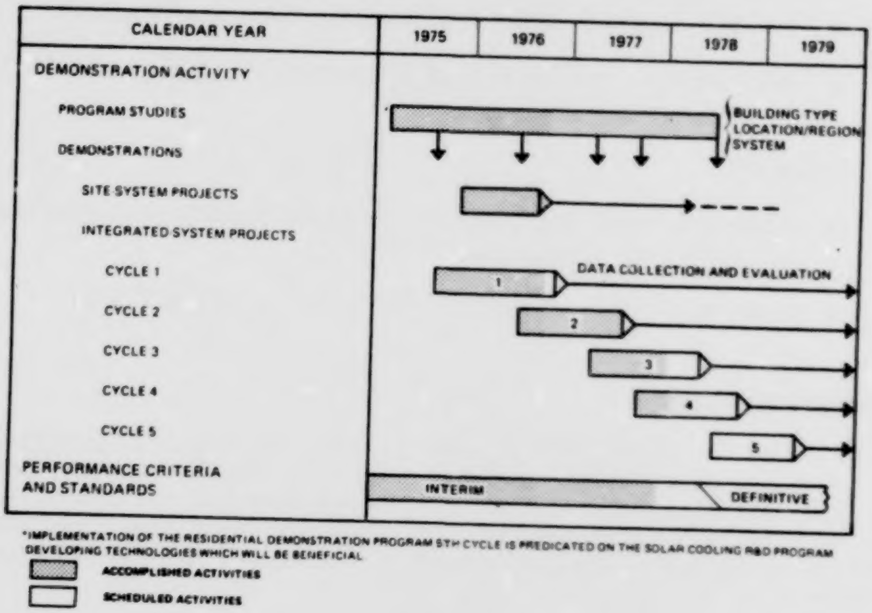
- Data Program
- Standards and Criteria

Residential Demonstrations*

Through three cycles activated in the Residential Demonstration Program to date, there are about 330 residential solar heating and cooling projects -- involving over 5000 dwelling units -- initiated or in operation. The fourth cycle is now underway, with 520 grant applications received and under evaluation for awards of up to $8 million in FY 78. In addition, HUD/DOE are planning a passive solar residential design competition and demonstration to encourage builders to use passive technology. This design competition will be initiated during the summer of 1978. Figure 1 shows the Residential Demonstration Program activities and schedule.

FIGURE 1

HUD RESIDENTIAL DEMONSTRATION PROGRAM



*IMPLEMENTATION OF THE RESIDENTIAL DEMONSTRATION PROGRAM 5TH CYCLE IS PREDICATED ON THE SOLAR COOLING R&D PROGRAM DEVELOPING TECHNOLOGIES WHICH WILL BE BENEFICIAL

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* The Residential Demonstration Program is managed for DOE by the Department of Housing and Urban Development (HUD).

The Residential Demonstration Program provides an opportunity for builder-developers and solar energy systems manufacturers and distributors to demonstrate and market their solar energy systems. In this program, the builder-developer proposes the location, building type, and solar energy system as part of his application for a project and incorporates the proposed system into a complete residential project package. These integrated projects provide information on the constraints facing project developers in regard to market acceptance and other important operational and market matters. Some of these projects are also being instrumented for more detailed technical evaluation of the solar system.

Applications for integrated-system projects are invited through nationwide Request for Grant Application (RFGA) solicitations. Three cycles of project awards have been made. The first solicitation brought some 250 applications in the fall of 1975; 55 projects were announced in January 1976, 41 of these are either complete or under construction. Over 300 applications were received in response to the second cycle RFGA, issued in July 1976, and 102 project awards were announced in October. Sixty-eight of these projects are complete or under construction. The third cycle RFGA was issued in January 1977 and resulted in over 700 applications, with 169 project awards announced in May. Award details of these solicitations are presented in Table 4.

The fourth cycle RFGA was issued in November 1977 calling for applications in January 1978. Five hundred and twenty-five applications were received and are currently being evaluated. A complete listing of the HUD residential demonstration projects are contained in the report "Solar Heating and Cooling Demonstration Project Summaries"(4).

The rapid development of the solar industry and the increasing technical sophistication of its products has brought solar service and domestic water heating technology to market readiness. To encourage the development of a market demand for solar water systems, DOE and HUD began a special solar hot water market initiative for residences in 1977. The HUD program involves grants to eleven states with particularly high electric rates and with large regional market potential to support a number of partial grants ($400 each) to individuals and builders. In response to this initiative, 10,867 proposals were accepted and 125 hot water systems are now operational.

Commercial Demonstrations

Demonstrations of solar heating and cooling on both Federal and non-Federal commercial building applications constitute a major element of the Demonstration Program. Like the Residential Demonstrations, they are being implemented in a cyclical manner to benefit from technological advances and experiences gained from previous projects. The cycles are implemented using Program Opportunity Notices (PONs) which identify bid opportunities for the private sector. The general plan for the commercial buiilding demonstration program is shown in Figure 2 with the shaded bar segments indicating progress to date.

TABLE 4

HUD RESIDENTIAL DEMONSTRATIONS INTEGRATED-SYSTEM PROGRAM

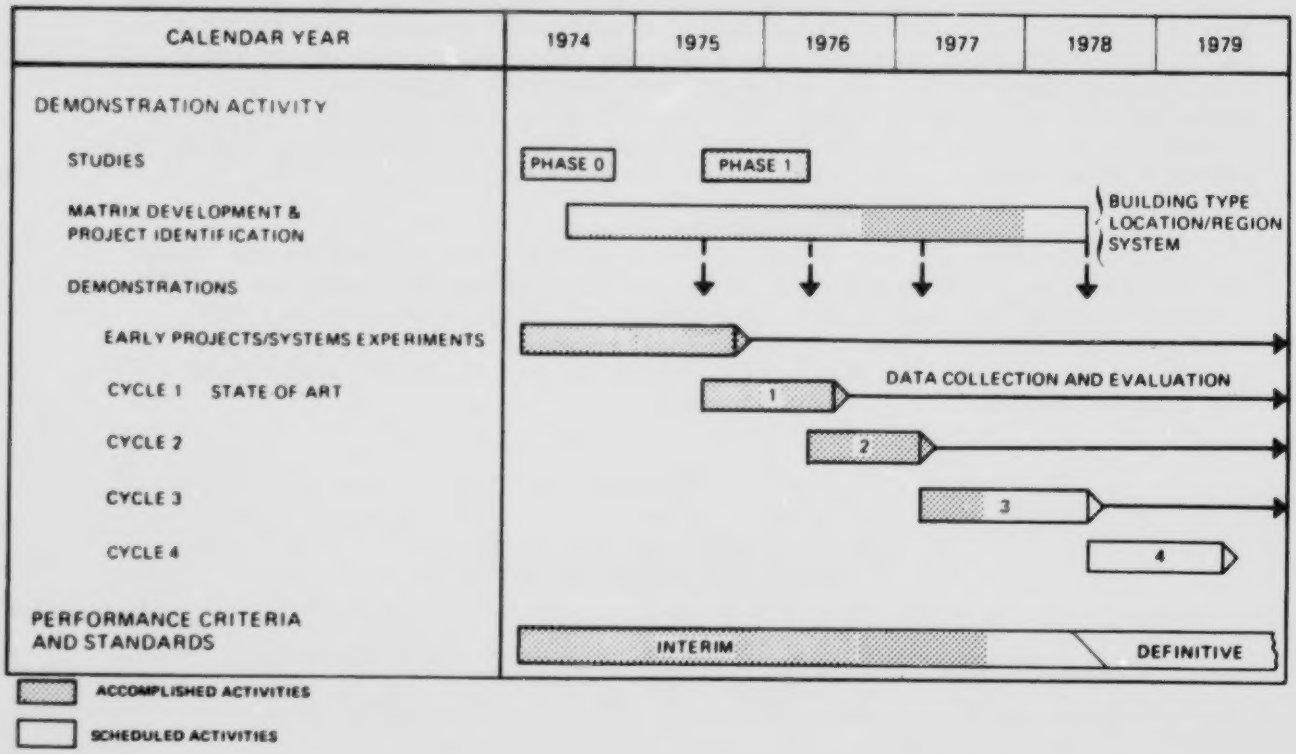
HUD RESIDENTIAL DEMONSTRATIONS INTEGRATED-SYSTEM PROJECTS	CYCLE 1 (AS SELECTED)			CYCLE 2 (AS SELECTED)			CYCLE 3 (AS SELECTED)		
	NUMBER OF UNITS	NUMBER OF PROJECTS	TOTAL GRANT AMOUNT	NUMBER OF UNITS	NUMBER OF PROJECTS	TOTAL GRANT AMOUNT	NUMBER OF UNITS	NUMBER OF PROJECTS	TOTAL GRANT AMOUNT
TYPES OF GRANTEES									
Builders/Developers	82	44	$ 728,489	1,011	87	$2,817,863	2,400	143	$4,598,000
Local Governments	54	8	281,785	308	13	773,961	647	17	1,198,000
Universities	7	3	33,960	92	2	321,500	417	7	242,000
	143	55	$1,044,234	1,411	102	$3,913,324	3,464	167	$6,038,000

UNIT AND SOLAR APPLICATION MIX	CYCLE 1 NUMBER OF UNITS	CYCLE 2 NUMBER OF UNITS	CYCLE 3 NUMBER OF UNITS
SINGLE FAMILY			
Heating Only	2	2	5
Hot Water Only	13	110	44
Heating and Hot Water	76	232	322
Heating and Cooling	6	4	1
Heating, Cooling and Hot Water	5	28	2
	102	376	374
MULTI-FAMILY			
Heating Only	–	–	40
Hot Water Only	21	670	2,373
Heating and Hot Water	20	273	669
Heating and Cooling	–	–	–
Heating, Cooling and Hot Water	–	92	12
	41	1,035	3,094
ALL UNITS			
Heating Only	2	2	45
Hot Water Only	34	780	2,417
Heating and Hot Water	96	505	991
Heating and Cooling	6	4	1
Heating, Cooling and Hot Water	5	120	14
	143	1,411	3,468

EXISTING VS. NEW CONSTRUCTION	CYCLE 1 NUMBER OF UNITS			CYCLE 2 NUMBER OF UNITS			CYCLE 3 NUMBER OF UNITS		
	TOTAL	EXISTING	NEW CONST.	TOTAL	EXISTING	NEW CONST.	TOTAL	EXISTING	NEW CONST.
SINGLE FAMILY	102	12	90	376	71	305	374	26	348
MULTI-FAMILY	41	21	20	1,035	583	452	3,094	2,376	718
	143	33	110	1,411	654	757	3,468	2,402	1,066

FIGURE 2

COMMERCIAL DEMONSTRATION PROGRAM



In 1974, an initial series of four Proof-of-Concept experiments in non-Federal commercial buildings was supported by the National Science Foundation (NSF). In January 1975, responsibility for these experimental projects, along with 14 additional non-Federal commercial demonstrations, was transferred to ERDA and subsequently to DOE. The four initial Proof-of Concept experiments are complete. Eight of the fourteen additional projects initiated by NSF are in the operational test phase.

Because a representative mixture of demonstration projects was imperative for planning purposes early in the program, a Phase 1 program was initiated in which study contractors were required to identify and submit for consideration specific demonstration project opportunities. Of the initial recommendations, 11 projects were identified as having potential and the building owners were invited to submit proposals for cost-sharing contracts. Eight projects were eventually selected, one is operational, and the remaining seven are now nearing completion (3).

The first cycle of the Commercial Demonstration Program began in the Fall of 1975 with a call for proposals to incorporate solar energy in new or existing buildings, with primary emphasis on space heating and hot water systems. Thirty-two projects in twenty-two states and the Virgin Islands were selected from among 308 responses to the first cycle PON; 11 are now operational. The second demonstration cycle was initiated with the release of PON-2 in October 1976. This cycle accommodated a wider range of solar applications and building types and required specific attention to energy conservation techniques. Seventy-four projects in thirty-two states were selected from among the responses to the second cycle PON; nine are now operational. The scope of the Commercial Demonstration Program was expanded with the release in May 1977 of a Hot Water Initiative for Hotel/Motel Installations. Fifty projects in twenty-seven states and the Virgin Islands were selected from among the 121 responses to the Hot Water Initiative PON; one is now operational.

The third cycle has been recently initiated with the release of the third cycle Program Opportunity Notice in November 1977 with awards expected in 1978. Combined heating and cooling will be emphasized equally with mandatory cost-sharing at an increased level expected for incremental solar system costs. A summary of the current 187 non-Federal commercial demonstration projects by building type and application is given in Table 5.

TABLE 5

DOE COMMERCIAL NON-FEDERAL DEMONSTRATION PROJECTS

COMMERCIAL NON-FEDERAL DEMONSTRATION PROJECTS	EARLY NSF PROJECTS TOTAL GRANT AMOUNT $9,800,000*	PHASE I PROJECTS TOTAL GRANT AMOUNT $2,400,00*	PON I PROJECTS TOTAL GRANT AMOUNT $8,000,000*	PON II PROJECTS TOTAL GRANT AMOUNT $12,000,000*	HOT WATER INITIATIVE PROJECTS TOTAL GRANT AMOUNT $4,000,000*
BUILDING TYPE AND SOLAR APPLICATION MIX	NUMBER OF PROJECTS	NUMBER OF PROJECTS	NUMBER OF PROJECTS	NUMBER OF PROJECTS	NUMBER OF PROJECTS
SCHOOLS/UNIVERSITIES					
HEATING/COOLING ONLY	1			6	
HOT WATER ONLY	1				
HEATING/COOLING AND HOT WATER	1		5	12	
HEATING AND COOLING	3		1	2	
HEATING, COOLING AND HOT WATER	3		1	2	
	9		7	22	
OFFICE BUILDINGS					
HEATING/COOLING ONLY		3	3	8	
HOT WATER ONLY			1	1	
HEATING/COOLING AND HOT WATER		1	3	9	
HEATING AND COOLING	2		1	3	
HEATING, COOLING, AND HOT WATER		1	3	3	
	2	5	11	24	
PUBLIC BUILDINGS					
HEATING/COOLING ONLY	1		2	2	
HOT WATER ONLY	1		1		
HEATING/COOLING AND HOT WATER	2		3	14	
HEATING AND COOLING			2	2	
HEATING, COOLING, AND HOT WATER	1	1		6	
	5	1	8	24	
HOTELS/MOTELS					
HEATING/COOLING ONLY			1		
HOT WATER ONLY	2	2			50
HEATING/COOLING AND HOT WATER			2	2	
HEATING AND COOLING					
HEATING, COOLING, AND HOT WATER				1	
	2	2	3	3	
COMMERCIAL/INDUSTRIAL BUILDINGS					
HEATING/COOLING ONLY			1	1	
HOT WATER ONLY			1		
HEATING/COOLING AND HOT WATER				4	
HEATING AND COOLING					
HEATING, COOLING, AND HOT WATER			1		
	0	0	3	5	
ALL BUILDING TYPES					
HEATING/COOLING ONLY	2	3	7	17	
HOT WATER ONLY	4	2	3	1	50
HEATING/COOLING AND HOT WATER	3	1	13	41	
HEATING AND COOLING	5		4	7	
HEATING, COOLING, AND HOT WATER	4	2	5	12	
	18	8	32	78	50

*ESTIMATES

Solar Data Program

The objectives of the Solar Data Program are to evaluate and publish the thermal performance of representative solar demonstration systems located throughout the United States; to evaluate and publish the operational performance and cost/benefits of solar demonstration systems; and to publish overall comparative analysis reports that will lead to the continuing improvements of future solar systems.

To facilitate data collection, a central data processing facility began operation in October 1976. Sixty solar systems have been instrumented and are currently transmitting engineering data. A total of 225 systems are planned for instrumentation by the end of FY 79.

The collection and evaluation of data from the demonstration projects and their dissemination to a wide range of potential users are key objectives of the solar heating and cooling Demonstration Program. These data must be readily understood by users so that they can be applied to decisions as to the selection and application of solar energy systems. Special emphasis is therefore being placed on the determination of user needs, standardization of data to allow system comparison, and close inter-agency coordination to minimize duplication of activities.

The Data Program also focuses upon non-instrumented projects, with emphasis on project descriptive documents, cost reports, maintenance and reliability, and data dissemination through the following:

- Technical Information Center
- Solar Heating and Cooling Information Center
- Solar Energy Research Institute
- Conferences
- Technical journals and
- Solar bulletins.

Standard and Criteria

Standards and criteria for solar system and subsystem design and performance are vital to reduce the uncertainties inherent in any new technology and to allow for adequate consumer protection. Federal agencies, especially the National Bureau of Standards (NBS), are cooperating with other organizations in the development of consensus standards, a system extensively utilized by governments and industries in the United States. The American National Standards Institute's Steering Committee on Solar Energy Standards Development is providing direction and continuity in this effort.

Interim performance criteria developed for both residential and commercial solar energy systems have been issued and will be updated as necessary to incorporate experience gained through the Demonstration Program. Definitive performance criteria for both commercial and residential applications will be established upon the conclusion of the program utilizing the knowledge and experience from the Demonstration Program.

A program is being conducted through the Solar Energy Research and Education Foundation (SEREF), which is under contract to DOE to develop and implement a solar collector rating, labeling, and certification program in accordance with consensus tests and standards. SEREF is an affiliate of the Solar Energy Industries Association (SEIA).

Intermediate Minimum Property Standards for solar heating and domestic hot water systems were developed in July 1977, by HUD. These standards apply to all housing built under programs of the Federal Housing Administration, Farmers Home Administration, and Veterans Administration.

Another activity within the standards and criteria area is the development of a model solar building code. Organizations such as architectural and engineering professional societies, state and local building officials, as well as DOE and HUD, have, under NBS sponsorship, been developing inputs to a model solar code. This activity will result in the development of model solar code provisions for possible inclusion in the various model building codes during FY 1979.

Finally, a standards workshop has been planned for 1978, which will allow interaction between solar professionals involved in consensus standards-making, industry, trade associations, and consumers. Such interaction is intended to accelerate the development of solar system standards.

FEDERAL BUILDINGS PROGRAM

The Federal Buildings program is another major element of the Solar Heating and Cooling Program. Its purpose is to stimulate growth and improve the efficiency of the solar industry by demonstration of federal confidence and support of the industry. The goal of the program is to provide assistance to Federal agencies over a three-year period, limited to the design, acquisition, construction, and installation of solar heating and cooling equipment in federal buildings. A maximum of $100 million is available in this program.

AGRICULTURAL AND INDUSTRIAL PROCESS HEAT

This program element, aimed at applying solar energy to useful thermal energy output for Agricultural and Industrial Process Heat (A&IPH) applications, is intended to provide the initiative for agriculture and industry to adopt solar energy as a replacement fuel. Specific objectives of the program are:

- Develop technology base by supporting experimental solar projects;
- Support large-scale A&IPH systems to demonstrate that they are reliable, proven, commercially available alternates to fossil fuel systems; and

- Reduce system costs.

Agricultural applications involving experiments and prototypical solar energy systems are: agricultural food processing; grain drying; crop drying (peanuts, forage and tobacco); heating of livestock shelters; and heating and cooling of greenhouses.

The Industrial Process Heat Program concerns the development of solar energy applications to industrial processes in three areas: low-temperature applications (below 212°F/100°C); intermediate-temperature (212°F/100°C to 350°F/176°C); and high-temperature applications (above 350°F/176°C). These process heat experiments include such uses of solar energy as dehydration of food (low temperature); low pressure steam for industrial uses (intermediate temperature); and production of high pressure steam and heat for chemical processes (high temperature).

Program Status

Fifty projects have been funded for Agricultural and Industrial Process Heat Applications as shown in Table 6.

TABLE 6

Agricultural Applications	No. Projects
Food processing	8
Grain drying	11
Crop drying	10
Livestock sheltering	11
Heating/cooling greenhouses	10
Commercial greenhouses	5
Process Heat Applications	
Hot water	3
Hot air	4
Steam	4

These projects are detailed in Ref. (5).

MARKET DEVELOPMENT

Market Development is an essential element of the DOE program to accelerate the commercialization of solar heating and cooling. Studies and analyses have been completed on economic and institutional aspects of solar deployment and numerous reports published. A regionalized nationwide outreach program providing solar information and education, training and certification programs are underway. Needed environmental and resource assessments in support of widespread use of solar heating and cooling are continuing. The market development program involves two key

e[illegible]. Technology Transfer and Commercialization.

Technology Transfer

Technology Transfer is the important link between the Solar Energy Research, Development, and Demonstration Program and the utilization of its proven technology by the solar industry and the public. In 1977, the Solar Technology Transfer Program was established to develop a synergistic operation, involving public and private organizations with resources which can amplify the program efforts.

The following Technology Transfer activities are underway:

- Dissemination of user-oriented information, such as documents and public media material;
- Support of exhibits, workshops and conferences;
- Identification of target opportunities for technologies with potential for accelerated commercialization;
- Development and implementation of a broad range of installer training and educational programs;
- Assistance to the industry implementation of solar; installer licensing and certification procedures;
- Stimulation of the utilization of solar energy linked with the development of jobs and small businesses in economically deprived communities;
- Development and implementation of a consumer representation Plan; and
- Development of an International Program aimed at less-developed countries.

Commercialization

The overall objectives of the Commercialization Program are (1) to identify and evaluate barriers to the development and commercialization of solar energy -- economic, legal, regulatory, and institutional; and (2) to recommend policies and actions to remove barriers and accelerate solar commercialization.

The major Commericialization Program Elements are:

- Solar economic modeling and analysis
- Economic and financial incentives
- Public utility/solar energy interface

- Legal regulatory and institutional issues
- Employment and manpower issues
- Marketing and consumer issues
- Regional, state and local issues
- International market analysis
- Solar commercialization planning.

Solar heating and cooling systems will be widely used only when there are easily recognized economic benefits to be derived from their use and when financial and institutional barriers and constraints have been overcome. A number of studies of the problems involved in the rapid development of a solar heating and cooling industry were prepared by DOE in 1977, including two reports presented to Congress in April 1977. "Interim Policy Options for Commercialization of Solar Heating and Cooling Systems" (6) contains a summary discusson of the major constraints to rapid development of the solar heating and cooling industry, policy options for dealing with the various constraints, and recommendations for additional research in each problem area. "Analysis of Policy Options for Accelerating Commercialization of Solar Heating and Cooling Systems" contains in-depth, comprehensive analyses of the issues discussed in (6).

Site and Land-Use Planning

Work has been initiated relating to solar site and land-use planning to ensure the proper placement and orientation of structures for optimum solar radiation collection, and to preclude possible shading of solar collectors by future construction on adjacent properties.

The problem of solar access in already developed areas is more complex due to the legal history of land ownership. Some of the background of this problem is discussed in a booklet entitled "Solar Access and Land Use: State of the Law, 1977," published and distributed by the National Solar Heating and Cooling Information Center. This booklet was developed by the Center from a report prepared for DOE by the Environmental Law Institute.

During 1977 several important studies of the solar energy/public utility interface were completed. A major section of "Analysis of Policy Options" was devoted to a discussion of the complex issues involved in the solar/utility interface and the possible policy options. Seminars and workshops were held where these issues were debated at great length. Other reports published in 1977 in which the relationship between dispersed solar heating and cooling systems and public utilities is analyzed include "Public Utility and Solar Energy Interface: An Assessment of Polity Options, the Impact of Active and Passive Solar Building Designs on Utility Peak Loads."

Numerous studies are underway in the other commercialization areas. These studies are summarized in (7) which provides reference to documents on these specific studies.

REFERENCES

1. National Program Plan for Research and Development in Solar Heating and Cooling (DOE/CS-0008).

2. National Program Plan for Research and Development in Solar Heating and Cooling, Interim Report (ERDA 76-144).

3. Solar Heating and Cooling Research and Development Project Summaries (DOE/CS-0010).

4. Solar Heating and Cooling Demonstration Project Summaries (DOE/CS-0009).

5. Solar Agricultural and Industrial Process Heat Project Summaries (not yet available).

6. Interim Policy Options for Commercialization of Solar Heating and Cooling Systems (FRDA 77-62).

7. National Program for Solar Heating and Cooling of Buildings (DOE/CS-0007).

ZERO ENERGY HOUSE GROUP: STATUS REPORT

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BACKGROUND

In the context of this pilot study, a Zero Energy House is one in which solar energy is used to meet the significantly reduced energy needs of buildings incorporating various energy conservation subsystems. Measures to reduce energy consumption include reduction of heat losses (through windows, walls, floors and ceilings), recovery of waste heat (from domestic hot water systems and exhaust air systems), and optimized integrated energy systems. The objectives of these projects is to study the performance of buildings which require essentially zero or minimal energy from conventional fuels and utilize various active or passive solar heating systems.

As a result of a common interest among several northern latitude countries in these types of low-energy dwellings, and the existence of a number of such projects in those countries, the Zero Energy House Group was formed as a subproject within the CCMS Solar Energy Pilot Study. The Zero Energy House Group, under the chairmanship of Professor V. Korsgaard of Denmark, has held three meetings to exchange information on the design and performance of solar-assisted energy-conserving dwellings. The first meeting in January 1975 was attended by technical experts from Denmark, Federal Republic of Germany, the Netherlands, Sweden, the United Kingdom and the United States. Canada joined the abovementioned countries as a participant in the second meeting held in May, 1975. These meetings have been reported in previous proceedings. The third meeting is summarized below.

SUMMARY OF THIRD ZERO ENERGY HOUSE GROUP MEETING

During December 8-9, 1977, nineteen representatives from seven countries (Canada, Denmark, Germany, The Netherlands, Sweden, United Kingdom, United States) met at the Royal Institute of Technology in Stockholm, Sweden for the third meeting of the CCMS Zero Energy House Group.

The objectives of the meeting were:

1. to discuss experiences and measurements of on-going low-energy house projects in the participating countries.

2. to inform the participants of recent developments in both national and private projects associated with low-energy houses.

Summaries of the presentations made on both on-going and new projects are given below. In addition to the presentations and discussions, the program included visits to the Täby Low Energy Project and the laboratory facilities at the Royal Institute of Technology.

Zero Energy House in Denmark - T. V. Esbensen

A report on the performance of the Zero Energy House project during the period 1976-77 was presented. With energy conservation arrangements such as highly-insulated construction, mobile insulation of the windows and heat recovery in the ventilating system, the heat requirement for space heating was calculated to 2300 kWh per year. During the winter period 1976/77 the heat requirement, however, was actually 5800 kWh. The main reason for this difference was unintentional infiltration and a higher rate of mechanical ventilation than originally calculated. The solar heating system consists of a 42 m^2 flat-plate solar collector and a seasonal water storage tank with a capacity of 30 m^3. This system was dimensioned to cover the heat requirement for space heating and hot water supply during the whole year. Due to a very small amount of solar radiation that winter and due to the bigger heat requirement for space heating, the solar heating system covered only about 43% of the heat requirement.

The Philips Experimental House in Aachen, FRG - W. Hermann

The heat requirement for the solar energy experimental house in Aachen, FRG, was measured at 4000 kWh in the winter period 1975/76. The solar energy system, consisting of 20 m^2 high-efficiency solar collectors and 2 heat storage tanks of 40 m^3 and 4 m^3, covered 70% of the heat requirements. As auxiliary heat, a heat pump has been used to extract heat from the large storage tank and, at times, from the waste water tank or the earth/air heat exchanger.

At the conclusion of the presentation it was stated that the reduction of heat losses in buildings and the rational use of energy do reduce the energy needs of buildings considerably. The experimental results show that it is possible to satisfy a large part of the remaining energy demand of well-designed buildings by solar energy. However, because of the load distribution, solar heating can only be achieved by using either a large collector area or seasonal storage, and this reduces the system efficiency.

Low-energy Houses in the U.S.A. - R. Rittelmann

The Energy Efficient Residence (EER) research and demonstration program was presented, a project sponsored by the U. S. Department of Housing and Urban Development. The purpose is to provide guidelines for cost-effective design and construction of energy conserving homes.

A wide range of energy conservation options have been investigated including design and orientation, insulation, windows, doors, heating/cooling systems, water heating and appliances, as well as some of the more sophisticated concepts. The most promising options which may be practical for the immediate future were incorporated into a demonstration house. The EER demonstration house will be monitored for one year following occupancy to determine the relative cost effectiveness of the special features. The Energy Efficient Residence is expected to require 1/3 to 1/2 less energy than a typical existing home.

Following completion of the testing program, a technical manual will be prepared with guidelines for building the most cost-effective energy conserving homes in different regions of the country, depending on local energy costs and seasonal extremes.

The Goosebrook Solar Home, New Hampshire, USA - B. Anderson

With the help of energy conserving design and through the use of active and passive solar energy systems, the heat requirement for the Goosebrook Solar Home is calculated to be less than one-fifth of the heat requirement for normal homes.

The active solar system uses water for transporting and storing the heat. The south-facing sloped roof is covered with simple, black corrugated aluminum collectors with a single glass cover. Water trickles directly over the panels and flows by gravity to the storage system in the basement.

The passive portion of Goosebrook's solar heating system consists of a small greenhouse, an all-glass south wall and a row of water-filled fiberglass cylinders inside the living-room, next to the glass wall. When sunlight enters the wall, it heats the water in the cylinders. At night, the water reradiates its stored warmth to provide space heating. To prevent night-time heat loss, the house has moveable insulating doors, that can cover the exterior of the glass wall at night.

Passive Solar Energy Building in Vetlanda, Sweden - E. Øfverholm

The aim has been to create a low-energy residence using current techniques, generally available components and an energy-conscious architectural planning.

Solar energy enters through windows (18 m^2) in the southern facade. Overly high indoor temperatures are avoided by means of room thermostats, a variable air flow and fixed solar screening. Heat losses are reduced by means of effective insulation (19 cm in walls and 30 cm in roofs), four-pane windows, and dense construction. The space heating load was calculated at 6900 kWh/year. Measurements were carried out in the building and in a reference building during the 1976/77 heating season and will continue in 1977/78.

The most serious potential problem with this project might be high indoor temperatures because of the large south facing glass screening. The roof overhand at the south facade is probably the reason why no extreme temperatures were reported during the last summer period.

The Täby Project, Sweden - Per Isaksson

The project is comprised of 41 houses, of which 27 are 1½ story attached houses, and 14 are 2-story terraced houses. The construction of the houses will be completed during spring 1978. Twenty-six houses are equipped with various types of energy-saving equipment. Four types of systems are being tested: 1)

Mechanical ventilation with heat recovery, 2) Systems with "demand-controlled" climate, 3) Solar heat collectors with storage tanks, and 4) Heat pumps.

A state subsidy has been granted for the various energy saving installations. In addition, the Swedish Council for Building Research provides financial support for the research effort.

The Low-Energy House Project in Denmark - M. R. Byberg

During the summer period 1978, six different low-energy houses will be constructed on adjacent lots in Lyngby, near Copenhagen. In this project a low-energy house is defined as a one-family house, 120 m^2, with a total heat demand for space heating and hot water supply of not more than 5000 kWh per year. The auxiliary heat supply of max. 5000 kWh includes electric supply to ventilators, water-pumps and heat-pumps.

Contributing to the heat supply will be heat gain from persons, electric lighting, solar heat gain through windows, solar energy systems and heat-pump systems. The low-energy houses will be monitored and evaluated very carefully by the Technical University of Denmark for a period of two years.

The Low-Energy Houses in Skive, Denmark - T. Esbensen

In 1977, the trade council in Skive arranged a competition for the design of low-energy single-family houses. Twenty-three different projects were received, and 9 of these were selected for construction at a joint area in Skive.

All the projects have energy conservation features, and 8 of the 9 selected houses have solar energy systems for heating and hot water supply. Some of the solar systems are combined with heat pumps, and one house has a combination of solar and wind energy systems. The houses are monitored and will be evaluated by the Institute of Technology in Copenhagen.

The Autarkic Housing Project, United Kingdom - John F. G. Littler

The project to devise a self-sufficient house, completely independent of the network services of gas, water, electricity and drainage, was initiated at the University of Cambridge, Department of Architecture, in 1971. The main objective is the construction of a house deriving its energy and resource requirements from solar and wind power, the collection of rainwater and the recycling of its own wastes.

Discussion on Future Cooperation

The future of the cooperative activities of the Zero Energy House Group was discussed. The various options considered were:

1) Continuing the activities under CCMS (during the follow-up period) and

then independently.

2) Transferring the activity to the IEA Solar Heating and Cooling Program.

3) Concluding the group's activities.

The delegates favored the continuation of the work of the Zero Energy House Group which they considered to be very effective. Since all the Zero Energy House Group participants are members of the IEA, it was decided to transfer the cooperation to the IEA program. This approach was approved at the pilot study meeting in Dusseldorf.

MEDITERRANEAN APPLICATIONS GROUP: STATUS REPORT

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and

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BACKGROUND

As a result of the successful interchange of the CCMS Zero Energy House Group which shared the experiences of northern latitude countries with low-energy dwellings, it was decided at the 1975 CCMS meeting in Palo Alto, California, to consider the establishment of additional subprojects relating to solar utilization in other climatic regions. The Mediterranean working group was formed as a result of this decision.

At the 1976 pilot study meeting in Copenhagen, the following countries joined to form a Mediterranean Applications Group: France, Federal Republic of Germany, Greece, Israel, Saudi Arabia, Spain, Turkey, and the United States. Subsequently, Australia, Iran, and Italy expressed interest in joining the group. It was made clear that participation was not limited to countries bordering on the Mediterranean, and that all countries with sufficient interest would be welcome to participate. France agreed to lead this group, with Dr. M. Rodot serving as Chairman.

The participants first formulated a definition of the "Mediterranean climate." This has the following characteristics:

- Relatively cool winters
- Short period of heating required, but with many sunny days
- Humid, relatively dry or dry summers
- Cooling frequently required in summer
- An abundance of clear days and nights.

Because of the relatively short heating period, it appeared that active solar heating systems would not be competitive, whereas passive heating methods might be. It was also considered important that cooling during hot periods be accomplished by simple methods, if possible.

The participants then outlined specific facets of solar energy appropriate to this climate, with the intention that many of these applications would be the subject of close cooperation within the group. These applications were:

- Passive heating and cooling systems, designated as the focus of a special effort

- Studies of the traditional living environment, concentrating especially on the material and sociological aspects of regional dwellings

- Cooling methods using evaporation

- Cooling methods using nocturnal radiation and cool night air

- Solar ponds, which may be particularly appropriate to this type of climate

- Techniques for conserving water

- Systems of water distillation, whether or not associated with the production of mineral salts

- Specific aspects of meteorology, particularly those bearing on nocturnal radiation.

It was recognized that additional topics might be added to this preliminary list or certain items deleted.

It was agreed to hold a meeting of all interested participants in France during 1977; this meeting is summarized below.

THE 1977 MEETING OF THE MEDITERRANEAN APPLICATIONS GROUP

The first meeting of the Mediterranean Applications Group was held at Nice, France during October 10-12, 1977. The working sessions took place at the Observatory of Nice. Following these a tour of local solar installation was conducted. More than thirty people attended, representing the following countries: France, Federal Republic of Germany, Iran, Israel, Italy, Monaco, Saudi Arabia, Spain, and the United States. The European Commission also participated. The program included fifteen presentations, grouped in three sessions.

Session 1

The first session consisted of the presentation of national solar activities, especially passive heating and cooling techniques, including demonstration projects. Pertinent programs of France, Italy, Saudi Arabia, Spain, the United States and the European Commission were presented. A number of major documents were exchanged among the participants.

Session 2

This session, together with Session 1, produced discussions of many problems related to passive heating. Some of the main conclusions are summarized below:

- Solutions of multi-node thermal network equations have allowed the prediction of the behavior of storage wall systems (including Trombe walls) and roof-pond systems. Work is in progress on calculating the behavior of direct-gain houses, attached greenhouse structures, and thermosiphon-heated buildings.

- Temperature regulation in some of these systems may be a problem which will influence the acceptability of the systems. In this respect, buildings equipped with thermosiphon collector/storage systems and forced air or water distribution systems may produce more uniform temperatures than the other type of systems.

- For thermal storage walls, water is best, and concrete is better than adobe. The interior air temperature variation decreases as the wall thickness increases, 40 cm of concrete being sufficient to produce acceptably small temperature fluctuations.

- Concrete walls containing water or latent-heat-of-fusion material are under development.

- The use of movable insulation is highly desirable to prevent heat loss at night in winter and to minimize heat gain during the day in summer. Much work is in progress to devise forms of movable insulation which will have sufficiently long lifetimes.

- Diffusing windows appear to be quite important for the successful operation of direct-gain systems.

- Initial indications are that theoretical computation will be possible soon for all types of passive structures and will allow the prediction of the thermal behavior of these structures in many different climates. However, much work in thermal modeling and computer code validation remains to be done.

Session 3

This session mainly comprised a review of passive cooling including natural cooling by nocturnal radiation, cool night air, and evaporation. The use of solar-assisted heat pumps and absorption air conditioning was discussed briefly. Some tentative conclusions from the discussions are given:

- Many traditional houses in Europe, in Arab countries, and in Africa indicate the important influence of insulation and thermal inertia, and the desirability of designs which allow use of radiation, cool night air, or evaporation for cooling. Many designs and techniques have evolved over thousands of years. However, there is little quantification of these techniques and geometrics.

- Radiative cooling is well understood in that there is abundant knowledge of infrared radiation, its absorption by humidity in the air, and the use of appropriate selective surfaces. It appears that it should be possible to achieve a cooling power of 10 to 50 W/m^2 of radiator, depending on temperature differences and on convection losses. Practical components and their integration into buildings need further study. It was stated that work is in progress on radiators which could perform during the day. System experimentation with radiators at various sites could be used to verify theoretical predictions and, therefore, to establish the effectiveness of radiative cooling in many climates.

- Evaporation can be used in dry climates in various ways to produce cooling power up to 300 W/m^2. Mathematical modeling is proceeding well; however, more work is needed to develop new methods of coupling evaporation with convection and/or with storage, and new ways of minimizing the undesirable effects of humidification of air. Several concepts are possible, ranging from primitive, inexpensive configurations to sophisticated, expensive ones.
- Economic analyses are needed to assess the practicality of radiative and evaporative cooling in various climatic zones.
- Active solar methods using traditional heat pumps and lithium bromide absorption air conditioners are also of interest. Again, a study of the economics of these cooling-machine systems is important.

General Discussion and Conclusions

Following these presentations, there was a general discussion aimed at defining the main research and development problems involved with solar heating and cooling, desirable actions to be taken in the dissemination of information, and future cooperation. Based on these discussions, the following conclusions were reached as to the areas appropriate for continued cooperation in the Mediterranean Group:

- Concentrate on systems assessment. This implies the use of components like Trombe walls, radiators, evaporators, variable conductivity walls, greenhouses, storage, etc., but in the context of complete thermal systems.
- The CCMS System Performance Reporting Format is recommended for reports on any completed projects. The CCMS format should be modified to be appropriate for passive systems.
- Concentrate on passive systems, augmented by simple active solar systems or by standard back-up systems, for either heating or cooling.
- Continue the development of mathematical models to characterize solar systems so that the effectiveness of either heating or cooling can be predicted as functions of system variations or climatic variations.
- Conduct separate studies for new individual dwellings, new collective houses, retrofitting old houses and, industrial buildings. These all appear to be worth experimentation, but in somewhat different perspectives.

- Extend existing or planned experiments on systems in two directions:

  (a) characterize acceptable room temperature variations and humidity from a comfort point of view, and

  (b) implement more physically meaningful instrumentation such as infrared mapping.

- Classify and quantify the various types of passive heating and cooling which abound in the countries surrounding the Mediterranean Sea, so that these techniques can be made available to all countries around the Mediterranean and to the rest of the world.

- The information exchange which occurred at the first meeting of the Mediterranean Applications Group was definitely worthwhile. It should be continued and improved, if possible.*

FUTURE COOPERATIVE EFFORTS

At the Düsseldorf meeting, the pilot study participants agreed that the activities of the Mediterranean Applications Group should continue in a CCMS framework, for at least part of the follow-up period. During that time a suitable international organization will be sought as sponsor for the group.

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*A second meeting has been scheduled for Fall 1978.

REPORT OF THE SYSTEM REPORTING FORMAT COMMITTEE

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INTRODUCTION

In 1974, a committee was formed at the CCMS Solar Energy Pilot Study Meeting in Odeillo to develop a System Reporting Format to provide guidelines for reporting measured performance of solar heating and/or cooling systems. The objective was to assure that sufficient information was provided in a CCMS performance report to enable the reader to make his own assessment of the system and to relate measured performance obtained in a particular climate and economic environment, to a different climate and economic environment. Following its adoption at the Palo Alto Conference in 1975, the CCMS Reporting Format was introduced into the CCMS information exchange network and the exchange of format reports began. The exchange process culminated in the presentation of sixteen format reports at the 1978 CCMS/ISES Conference on the Performance of Solar Heating and Cooling Systems held in Dusseldorf.

BACKGROUND HIGHLIGHTS

The CCMS Reporting Format development and application activities in the 1974-1978 period were highlighted by the following events:

- 1974 - draft of CCMS Reporting Format at Odeillo meeting.
- 1975 - Palo Alto Conference adoption of the "Recommended CCMS System Reporting Format."
- 1976-1978 - CCMS countries exchange System Format Reports.
- 1976 - CCMS Format Committee meeting review of experience with the Recommended CCMS System Reporting Format.
- 1976 - CCMS Solar Energy Pilot Study meeting. Recommendation that a formal summary outline be drafted and that no change be made in the format until additional experience is gained.
- 1976 - adoption by IEA of the CCMS System Reporting Format as the basis for development of an IEA System Reporting Format.
- 1977 - Distribution of Swedish document with detailed interpretive comments on the Format.
- 1977 - CCMS Format Committee assistance to the IEA Format Task group.

- 1978 - Authors' utilization of format and format summary outline in the preparation of extended abstracts and in their preparation of full performance reports for CCMS/ISES Conference.

DISCUSSION

Comments received by the Format Committee in the 1976-78 period have contained a variety of suggestions relating to the application and interpretation of the CCMS System Reporting Format. There is general agreement that:

1) It is important that authors adhere to the format as closely as possible in order to set a professional standard of complete and orderly reporting of measured system performance.

2) Some flexibility in interpreting the format requirements must be granted inasmuch as solar heating and/or cooling systems are in their innovative stage of development.

3) The depth of system performance detail available to be reported is a direct function of project budget and volunteer effort, hence system format reports will vary in length.

Detailed comments on the CCMS System Reporting Format have been submitted by authors and readers. The most comprehensive set of comments is contained in the document, "Reporting Format for Solar Energy Buildings: An Outline," published by the Swedish Council for Building Research as Document D1: 1977 and distributed via the CCMS Solar Energy Pilot Study information dissemination system. The Format Committee recommends this document as an author's guide. Other comments received are the suggestions that:

1) The building should be described as an element of the system.

2) Daily energy values should be included in order to allow the reader to understand those system energy dynamics that disappear when only monthly values are reported.

3) Weekly energy totals may be added for industrial projects.

4) Hourly energy values over a sample span of days may be included for the information of readers who are system computer simulation experts.

5) The SI system of energy units should be adhered to, with the KWhr used paranthetically.

6) Systems and instrumentation periodically fail to operate; therefore such "down times" should be reported and their effect on the results should be carefully noted.

7) Instrumentation and data reduction discussions should include statements of calibration results, energy/mass balance discrepancies and the resultant accuracy of derived quantities.

8) Energy required for pumps and fans should be reported via performance factors such as coeffient of performance.

9) Collector efficiency should be evaluated on both a daily basis and a "collector-on" basis.

10) System economics are a strong function of the research nature of the system project; therefore care should be taken in reporting only those economics pertaining to conventional use.

Turning to the "Format Summary Outline," a draft was prepared and circulated to Format Committee members early in 1978. This outline is intended to be used for preparation of a summary (or extended abstract) of a full performance report. Subsequently received comments were incorporated into the final document which was then used as the specified abstract form for the sixteen papers submitted by ten countries to the Düsseldorf CCMS/ISES Conference on the Performance of Solar Heating and Cooling Systems. The Format Summary Outline may be found in Appendix F.

In related Format Committee acitivities, discussions were held in October 1977 and April 1978 between the CCMS Format Committee and the IEA Format Task Group. These discussions focussed on thermal performance definitions and the IEA format draft in which the National Bureau of Standards draft definitions and designations (e.g., Q100 for collected heat) had been incorporated. Sample energy flow diagrams were discussed. In CCMS Format Reports, it is essential that definitions, designations and an energy flow diagram be included. The distributed Swedish Building Council Document D1:1977 gives a sample energy flow diagram. Definitions and flow diagrams are given in the NBS definitions document, "Thermal Data Requirements and Performance Evaluation Procedures for the National Solar Heating and Cooling Demonstration Program," #NBSIR 76-1137, Center for Building Technology, National Bureau of Standards, Washington, D. C. 20234. This document has been distributed via the CCMS information dissemination system.

The CCMS Format Committee's coordination with the IEA Format Task group in 1977 and 1978 had transmitted the essential CCMS format experience to the IES group. This coordination smoothed the way for the ultimate phase-in of the IEA format as the successor to the CCMS format.

At the 1978 CCMS Solar Energy Pilot Study meeting, there was a discussion of the ending of the formal phase of the Solar Energy Pilot Study and the initiation of a two-year follow-up period. It was noted that the CCMS System Reporting Format, the Format Summary Outline, and the comments of CCMS authors and readers had been transmitted to the IEA Format Task by the CCMS Format Committee. It was then decided to undertake a phasing-out of the CCMS System Reporting Format in the follow-up period and to phase-in the IEA Format after it has been completed and distributed via the CCMS information exchange network and after CCMS countries have had an opportunity to submit comments to the IEA Format Task Group.

CONCLUSIONS

- The CCMS information program has made available to its participants the CCMS System Reporting Format, the CCMS Format Summary Outline, the Swedish Format Document D1:1977, the NBS definitions document NBSIR 76-1137, and a variety of System Format Reports.

- Liason has been maintained between the CCMS Format Committee and the IEA Format Task group and copies of all pertinent CCMS Format material have been transmitted to the IEA Format Task group.

- The CCMS System Reporting Format will be phased out in the follow-up period after CCMS participants receive and comment on the IEA Draft Format and as a subsequent IEA Revised Format becomes available through the CCMS network.

FOLLOW-UP ACTIONS

BACKGROUND

At the completion of a CCMS pilot study, the participants set forth, in a final report, their recommendations for future action on the national level and international level. A two-year follow-up period is then initiated for the study during which time the recommendations are acted upon and annual reports on the progress of their implementation are made to the CCMS.

The Solar Energy Pilot Study will present its Final Report at the Fall 1978 CCMS Plenary meeting. In preparation, the pilot and co-pilot countries formulated a set of recommended actions for continued international cooperation in solar heating and cooling buildings, specificially regarding those activities which had been conducted under the pilot study. These were transmitted to the Contact Persons for their review prior to discussion at the Düsseldorf Meeting.

At the April 1978 meeting, extensive discussions were held on the proposed recommendations and consensus reached on their content. During that time, there was considerable expression of appreciation for the pilot study's activities and its positive influence on emerging solar research and development programs, and the desire for continued international cooperation is reflected in the agreed-upon actions. (Recommendations for action at the national level were formulated at a later date and are contained in the Final Report.)

The proposed follow-up actions, listed below, were subsequently approved by the participants' Memorandum of Understanding signatory agencies. After presentation to the CCMS in October 1978, these recommendations will be implemented.

RECOMMENDATIONS FOR FOLLOW-UP ACTION ON THE INTERNATIONAL LEVEL

SYSTEM REPORTING FORMAT

Recognizing the strong commitment to CCMS Solar Energy Pilot Study participating countries to the use of CCMS System Reporting Format and to the exchange of format reports on the measured system performance of solar heating, cooling, industrial process, and domestic hot water systems; the existence of the CCMS information exchange network; and the progress of the International Energy Agency (IEA) Solar Heating and Cooling Task I Sub-group in refining the 1975 CCMS Format,

It is hereby recommended that:

(1) the work of the CCMS System Performance Reporting Format Committee be terminated and the modifications of the format be continued under IEA-Task 1,

(2) the CCMS System Performance Reporting Format, the Format Summary Outline, and the existing comments on improving the CCMS Format be transmitted to IEA-Task I,

(3) subsequent to drafting of the IEA System Reporting Format (based on the CCMS Format and Summary Outline), the IEA draft be distributed via the CCMS information exchange network,

(4) the CCMS participants transmit their comments on the new Format to the CCMS Pilot Study Director,

(5) the CCMS participants suggest to the IEA Format Committee the title "Solar Heating and Cooling System Performance Reporting Format," which is neutral with respect to IEA, CCMS, and any other affiliation,

(6) continued preparation and distribution of system performance reports be encouraged and that the reports be prepared following the CCMS Summary Outline and/or the CCMS System Performance Reporting Format until the IEA completes the new format, after which time the latter format would be available for utilization by the CCMS participants, and

(7) during the follow-up period CCMS participants report on their use of the format to the Pilot Study Director.

ZERO ENERGY HOUSE GROUP

In recognition of the valuable and practical work done by this group, the ongoing collaboration of all its members in IEA, and in view of the continuing interest in the results of projects carried out under its auspices by a large number of the Pilot Study participating countries,

It is hereby recommended that:

(1) the IEA be requested to approve the transfer of the work of the Zero Energy House Group to the IEA Solar Heating and Cooling Program,

(2) the IEA be requested to provide annual status reports on the group's activities to the CCMS Solar Energy Pilot Study Director during the two-year follow-up period, and

(3) the IEA be requested to hold at least one open technical conference on solar-assisted minimum energy dwellings, around the end of the CCMS follow-up period.

MEDITERRANEAN APPLICATIONS GROUP

In view of the later commencement of the work of this group and its significant remaining tasks to be accomplished, and considering the current participants and potential participating countries who are not currently involved in such work in any other international forum,

It is hereby recommended that during the follow-up period of two years:

(1) this group continue, in the CCMS framework, its cooperative efforts aimed at quantitative simulation and experimentation in solar houses in Mediterranean-type climates, principally based on passive heating and cooling systems,

(2) the possible transfer of this activity to another international organization be explored, with the condition that all present members be allowed to continue participation in the group and other countries be permitted to join, and

(3) the CCMS Pilot Study participants be regularly informed about the possibilities for such a transfer and, if no single organization proves feasible, consider further work within the CCMS framework.

REVIEW OF NATIONAL SOLAR HEATING AND COOLING PROGRAMS

Given the expression of interest in, and assessed value of, the annual reports on national solar heating and cooling programs, the existence of a well-established international professional organization with one of its objectives the sharing of information on solar energy programs and applications, and the success of the existing CCMS information exchange program,

It is hereby recommended that:

(1) during the 2-year follow-up period the continued circulation of written status reports on national solar heating and cooling programs be encouraged, and

(2) the transfer of this activity to the International Solar Energy Society be explored, with the intention that presentation of national solar heating and cooling plans be continued at a special session of the bi-annual meetings of the International Solar Energy Society. The CCMS Solar Energy Pilot Study would encourage (a) preparation of reports according to a recommended content outline, (b) consideration of smaller, more specialized meetings for the review of these national programs, and (c) the issuance of a proceedings document for national programs reports (as a separate document or as one of a series of documents resulting from the ISES Conference).

MEMORANDUM OF UNDERSTANDING

It is recommended that the Memorandum of Understanding continue in effect during the two-year follow-up period. The continuation or termination of the MOU at the end of the follow-up period will be addressed prior to the preparation of the final Follow-up Report (October 1980).

CCMS/ISES CONFERENCE ON THE PERFORMANCE AND COOLING SYSTEMS OF SOLAR HEATING

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A technical conference, the CCMS/ISES Conference on the Performance of Solar Heating and Cooling Systems, was convened in conjunction with the fourth Solar Energy Pilot Study meeting and was held at the Congress Center in Düsseldorf, Federal Republic of Germany on April 19-20, immediately following the 1978 pilot study meeting. The conference was planned as a public forum for the delivery of CCMS System Format Reports on the measured performance of systems which had been operational for at least one complete heating and/or cooling season. It was the first international conference devoted exclusively to reporting of such measured performance of solar heating and cooling systems in buildings and it was the first public technical conference sponsored by the CCMS Solar Energy Pilot Study. The conference was co-sponsored by the German Section of the International Solar Energy Society, with assistance provided by the German Ministry for Research and Technology, the Kernforschungsanlage Jülich, the German Solar Energy Industries Association, the German Solar Energy Society, the Society of German Engineers, and the U. S. Department of Energy.

The two-day CCMS/ISES Conference was attended by some 200 engineers, scientists, government officials and businessmen. The conference included a lecture on the CCMS System Performance Reporting Format which briefly reviewed the purpose and structure of the format, emphasizing the main elements of environment, system description, system performance description, economics, and sub-system characteristics. A joint FRG-USA lecture provided an overview of the papers, presenting a comparison of system types, sizes and performance. A lecture given on the prospects of solar heating and cooling in the USA set forth the wide array of system types being studied and demonstrated under Federal sponsorship. An FRG lecturer presented a computer simulation study which drew a comparison between hypothetical solar and conservation alternatives, and showed a technique for establishing the crossover point where the former would be favored over the latter. The advantage of passive systems was discussed and samples of buildings were shown pictorially by a US speaker.

The sixteen system performance reports given at the conference included residential, public building, swimming pool and industrial process solar applications in ten countries. Report topics are listed by application category in Table 1. In Table 2 project location and system characteristics are listed, and it can be noted that system collector areas ranged from 20 to 1500m^2, with all but one air-cooled collector utilizing water or water/glycol as the coolant. Flat plate, heat pipe, and evacuated tubular collectors, as well as passive gain, were represented. Space heating and domestic hot water heating dominated the applications. Three heat pump applications, two swimming pool applications and one industrial hot water project were included. Three heating projects were fitted for cooling as well as heating. Cooling subsystems were of the absorption type. Annual solar heat reaching an end-use of heating or end-use heat input to a cooling component ranged from 0.5 to 1.7 gigajoules per m^2 of collector, corresponding to the equivalent heat of combustion of approximately 5 to 17 gallons of oil at 70 percent combustion efficiency.

Available at the meeting were abstracts of each performance report prepared in accordance with a Format Summary Outline drawn up by the CCMS Format Group. Many speakers found it convenient to adhere to the CCMS Format Summary topics in chronological order in making their presentations. Others made use of the format topics in ways that fitted the project being presented. Useful informal exchanges took place between representatives of the CCMS Format Group, the IEA Format Task Group and the sixteen authors. In these exchanges, the strengths and weaknesses of the format were noted for the future information of the IEA Format Task Group which will continue the format development initiated under this CCMS Energy Pilot Study.

A panel of experts from Denmark, France, Federal Republic of Germany, and the United States held a discussion at the end of the meeting and emphasized: 1) The uniqueness of this particular meeting at which papers were wholly devoted to real data on operating solar heating and cooling systems operating over most of the heating and/or cooling season, 2) The difficulty of accumulating such operating data, and 3) The importance of the procurement of continuous, long-time data to the development and application of solar heating and cooling systems in all countries.

The complete proceedings of the Conference (CCMS Report No. 85) are being compiled by the Kernforschungsanlage Jülich, Federal Republic of Germany. The proceedings will be sent to all attendees and be given wide distribution through the CCMS contact persons.

TABLE 1. CCMS/ISES CONFERENCE SYSTEM PERFORMANCE REPORTS

RESIDENTIAL SYSTEMS

House in Mississauga, Canada

Zero Energy House in Lyngby, Denmark

House in Blagnac, France

Dornier/RWE House in Essen, FRG

Messerschmitt-Bolkow-Blohm House in Otterfing, FRG

Philips Experimental House in Aachen, FRG

House of the Technical University, Eindhoven, The Netherlands

House at Titahi Bay, New Zealand

Passive Solar House in Vetlanda, Sweden

Passive Solar House in Marmaris, Turkey

Colorado State University House, USA

Colorado State University House II, USA

PUBLIC BUILDING SYSTEMS

Study Center in Los Alamos, USA

Community Center in Santa Clara, USA

OTHER APPLICATIONS

Industrial Process Can Warming in Queanbeyan, Australia

Outdoor Swimming Pool in Wiehl, FRG

TABLE 2. CHARACTERISTICS OF SYSTEMS REPORTED AT CCMS/ISES CONFERENCE

PROJECT	COLLECTOR					APPLICATIONS						ESTIMATED
(see also Table 1)	AREA m^2	FLAT PLATE	EVAC-UATED	WATER COOLED	AIR COOLED	SPACE HEATING	SPACE COOLING	HEAT PUMP	SWIM-MING POOL	DOMES-TIC HOT WATER	INDUS-TRIAL HOT WATER	ANNUAL SOLAR ENERGY SUPPLIED, GJ/m^2
Queanbeyan,Aust	94	●		●							●	1.7
Mississauga,Can	64	●		●		●		●		●		0.8
Lyngby, Denmark	40	●		●		●				●		0.7
Blagnac, France	30	●		●		●						-
Essen, FRG	65	●(a)		●		●		●	●	●		1.1
Otterfing, FRG	80	●		●		●				●		0.5
Aachen, FRG	20		●	●		●		●		●		0.6
Wiehl, FRG (b)	1500	●		●					●			0.6
Eindhoven, Neth	51	●		●		●						-
Titahi Bay, NZ	33	●		●		●				●		-
Vetlanda, Swede		(Passive)				●						-
Mamaris, Turkey		(Passive)				●						-
CSU House I,USA	40		●	●		●	●			●		-
CSU House II,USA	67	●			●	●	●(c)			●		-
Los Alamos, USA	716	●		●		●	●			●		1.5
Santa Clara,USA	660	●		●		●	●			●		1.6

(a) heat pipe
(b) Installation includes space heating, DHW, and heat pump. Swimming pool performance reported at conference.
(c) Nocturnal system

APPENDIX

APPENDIX A

1978 CCMS SOLAR ENERGY PILOT STUDY MEETING

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APPENDIX B

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APPENDIX C

CCMS SOLAR ENERGY PILOT STUDY
CENTRAL INFORMATION CONTACTS

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Post Office Box 89
East Melbourne, Victoria 3002

BELGIUM
DELHASSE
Programmation de la Politique Scientifique
8, rue de la Science
1040 Bruxelles

CANADA
Mr. E. Clyde, Head, Technical Services
Canada Institute for Scientific and Technical Information
National Research Council
Ottawa, Ontario K1A 0S2

DENMARK
Mr. C. E. Andersen
Danmarks tekniske Bibliotek
Bygning 101
Danmarks tekniske Højskole
2800 Lyngby

FEDERAL REPUBLIC OF GERMANY
Zentralbibliothek (ZB)
de Kernforschungsanlange Julich
z. Hd. Dr. Schroder
Postfach 1913
D-5170 Julich

FRANCE
Mr. J. P. Traisnel
PIRDES
282, Bd. St. Germain
75007 Paris

GREECE
Library
Nuclear Research Center "Democritos"
Aghia Paraskevi
Attica

IRAN
The Office of Solar Energy Research and Development
Room 609, Energy Planning and Coordination
Ministry of Energy of Iran
Varzesh Avenue
Tehran

PORTUGAL
Ms. Manuela Azevedo
Nucleo de Documentacao e Informacao
Direccao-Geral dos Combustiveis
Rua da Beneficencia No. 241
Lisboa

SPAIN
Centro De Estudios De La Energia
Agustin de Foxa, 29 - 1°
Madrid - 16

TURKEY
Enerji Dairesi Baskanligi
Enerji ve Tabii Kaynaklar Bakanligi
Ankara

UNITED KINGDOM
Mr. J. Chillag
British Library
Lending Division
Boston Spa
Wetherby, West Yorkshire LS 23 7 BQ

UNITED STATES
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APPENDIX D

MEMORANDUM OF UNDERSTANDING CONCERNING COOPERATIVE INFORMATION EXCHANGE RELATING TO THE DEVELOPMENT OF SOLAR HEATING AND COOLING SYSTEMS IN BUILDINGS

The agencies which have signed the Memorandum of Understanding,

Recognizing that there are within the territories of the governments of the parties to the Memorandum of Understanding, governmental and industrially-sponsored programs which collectively form a broad-based attack on the challenging energy problems facing our societies, and

Believing that international cooperation in the field of solar energy for heating and cooling processes in buildings will prove fruitful for all concerned, and desiring to undertake a comprehensive exchange of knowledge gained about the design, the technical characteristics, and the performance of solar energy systems and subsystems developed in the course of conducting and monitoring projects related to solar heating and cooling in buildings,

Agree as follows:

1. The aim of this Memorandum of Understanding is to encourage the cost-effective and practical application of solar energy to heating and cooling in residential, commercial, industrial, agricultural and public buildings. This aim shall be accomplished through the exchange of information related to research programs and experiments and by developing an agreed format for reporting performance characteristics of solar heating and cooling systems in such applications. Information respecting the performance of the major subsystems shall be included in the exchange, together with information respecting whole systems experiments relating to the effectiveness of solar energy in heating and cooling processes in buildings. Information exchange respecting both subsystems and whole systems shall, to the maximum feasible extent, include data relating the experiment to the thermal requirements and climatological and social conditions involved.

2. Each signatory of the Memorandum of Understanding shall appoint a representative through whom the information specified above shall be exchanged. Each signatory shall send to all other signatories special reports -- prepared in an agreed format -- on projects under the sponsorship or coordination, or with the participation of the signatory, at significant stages of work on solar heating and cooling processes in buildings, and of relevant and publically available reports concerned in whole or in part with the subject matter of the Memorandum of Understanding. Copies of (a) the special reports in the agreed format, (b) of the full reports upon reasonable request, and (c) of additional material of general interest shall be sent expeditiously to the representative designated by each

signatory. The signatories agree also to the maximum feasible extent to dispatch to the other signatories relevant information published by other governmental institutions, universities, private corporations and groups, and technical societies in their country.

3. Additionally, the parties will participate in meetings, which are expected to be held at least annually, for the review of research and development programs and for discussions and exchange of information and ideas for further research.

4. Participation in the agreements established by this Memorandum of Understanding and annexes is subject to the laws of the respective countries. This includes laws respecting the protection of proprietary data and rights in intellectual property, including patents and copyright. All signatories agree to respect any such rights as may be established in accordance with the laws of other signatories as may relate to this Memorandum of Understanding. Participation is further subject to the availability of appropriations to each signatory, as such availability may be determined in accordance with the legal processes of the government of the individual country.

5. The signatories shall exercise their best efforts hereunder to ensure that all data in the subject area of this Memorandum of Understanding can be exchanged and will not be subject to claims for confidential treatment of any kind. Where, however, a private contractor or grantee maintains such claims despite the efforts to avoid such claims required herein, the signatories shall encourage such contractors or grantees to exchange data subject to such claims with other signatories to this Memorandum of Understanding, through special agreements or otherwise.

6. It is contemplated that a number of detailed procedures will be developed for cooperative efforts between agencies and will be incorporated as annexes to the original of this Memorandum of Understanding. When two or more signatories to this Memorandum of Understanding develop more specific relationships on subprograms or projects within the field of this Memorandum of Understanding, details of any agreement or arrangement between them may be annexed to the original of this Memorandum of Understanding.

7. Any signatory may terminate its participation under this Memorandum of Understanding by written notification to all other signatories. Such termination shall be effective 60 days from the date of the notification.

8. The original of this Memorandum of Understanding shall be deposited with the Department of State of the United States of America, which shall transmit two copies of the Memorandum of Understanding to each agency which notifies its intention to become a party hereto. Both copies shall be signed and dated on behalf of the agency and one copy shall be returned to the Department of State, which shall inform all agencies of signatures.

9. This Memorandum of Understanding shall enter into force on July 1, 1975, with respect to those signatories which have signed the Memorandum of Understanding on or before that date. With respect to those which sign subsequently, it shall enter into force on the date of signature.

APPENDIX E

CCMS SOLAR ENERGY PILOT STUDY

SYSTEM PERFORMANCE REPORTING FORMAT FOR HEATING AND COOLING SYSTEMS IN BUILDINGS

The objective of this system reporting format is to ensure that sufficient information is provided to enable the reader to make his own assessment of the performance of a solar heating and/or cooling system and to relate that performance, which was carried out in one particular climate and economic environment, to a different climate and economic environment.

All details of the format are to be followed as completely as possible. In addition, information on all related back-up reports is requested, including specific instructions on how they may be obtained.

FORMAT FOR REPORTING SYSTEM PERFORMANCE

I. GENERAL DESCRIPTION OF SYSTEM PROJECT AND ENVIRONMENT

A. Objective of Project

- Brief description of objective and strategy of project, including duration and major milestones.

B. Description of the Environment

1. Climate

- Brief description of type of climate, according to the Trewartha* worldwide classification system.
- Annual rain and snow fall (mm per year).
- Description of typical sky conditions relative to "clear sky"; either average daily sunshine hours, number of sunshine hours per year, the percentage of maximum possible sunshine hours or annual average cloud cover fraction may be used.

2. Location

- Latitude, longitude, and altitude (in m) of system.
- Description of the configuration of the location and distance from solar or wind obstructions or significant geographic features (seas, mountains, etc., in km).
- Comment on air quality, i.e., dust precipitation.

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*G.T. Trewartha, An Introduction to Climate (McGraw Hill: New York, 1968).

3. Solar Radiation

   - Mean monthly global (total) and, if relevant, diffuse isolation on a surface whose orientation is described. The number of years over which this mean is defined should be specified, as well as the time intervals of the data.
   - Description of the measurement equipment.

4. Ambient Temperatures

   - Mean monthly dry and wet bulb temperatures (relative humidity may be used in place of wet bulb temperature).
   - Number and basis of degree-days of location.
   - Description of the measurement equipment.

5. Wind

   - Average monthly wind speed and prevailing direction (0-360° from North towards East).
   - Description of measuring equipment.

C. Description of System

1. Qualitative Description

   - Description of the entire system, as well as the solar system, by narrative, photographs, or drawings.

2. Quantitative Description

   - Description of the system performance characteristics, including schematic drawings.
   - Orientation* and inclination+ of collectors.
   - Control system description, performance characteristics, and location within the system. The operating modes should be described.
   - Measurement system description, performance characteristics (such as precision and repeatability), and location within the system.

II. SYSTEM THERMAL PERFORMANCE -- The information in sections A, B, C and D is essential and therefore should be as complete as possible.

A. Daily, Monthly and Annual Values** of the Mean Daily (Tabular or Graphical Form)

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* Angle between the projection of the sun's rays, at solar noon, on the horizontal plane and the projection of the normal to the collector on the horizontal plane.

+ Angle between horizontal and normal to collector.

** The monthly value of the mean daily quantities is the most important of the three. Daily values may be provided as optional information.

- Total energy required (thermal load, heating or cooling, on system).
- Supplemental energy required (amount, kind, and purpose).
- Solar energy incident on collectors.++
- Solar energy collected
- Solar energy used.

The criteria for the use of supplemental energy must be described.

B. Record of the Quality of Thermal Performance of the System (e.g., departure from the design temperature over reporting period).

C. Solar Contribution to Energy Requirements -- daily, monthly and annual values* of percent solar contribution to the energy requirements.

D. Monthly and Annual Energy or Fuel Savings -- based on primary fuel (state type).

E. Energy and Mass Balances

This information is of secondary importance in that it is this information that is used to determine quantities reported in IIA. If possible, it is suggested (optional) that a typical day be used to show:

- Significant energy flow rates -- additions and losses.
- Significant mass flow rates -- additions and losses.
- Temperature and pressure at critical locations.
- Temperature drop and pressure drop across major components.

III. SYSTEM ECONOMIC ANALYSIS

The following costs and factors should relate to the solar portion of the project but could also be specified for the entire project.

A. Total Cost of the Solar Portion of the System -- with a specific definition made of the interface between the solar and non-solar portions of the system. If possible, separate design costs from component and installation costs.

B. Labor Costs -- in man-hours and in local currency, for the installation of the system.

C. Materials Costs -- in weight or volume as appropriate and in local currency.

++ It is suggested that this be based on (at least) hourly values of the global (and/or direct, if appropriate) insolation measured in the plane of the collectors. If the global insolation is only measured on a horizontal surface, it should be so provided and the method used to determine the amount incident on the plane of the collectors should be described.

* The monthly value of the mean daily quantities is the most important of the three. Daily values may be provided as optional information.

D. Operational Costs -- including supplemental energy costs, in local currency.

Since operational costs depend on the assumed system lifetime, it is suggested that the assumed system lifetime be stated along with the depreciation rate.

E. Local Economic Factors -- such as inflation, interest rates and amortization periods.

F. Expected Selling Price or Costs -- assuming that the system or solar components are mass produced.

G. Maintenance Frequency and Costs -- in hours and material.

H. User Reactions and Comments.

IV. CONCLUSIONS

FORMAT FOR REPORTING SUB-SYSTEM PERFORMANCE

A. SOLAR COLLECTORS

1. Description of Physical Configuration

- Description of solar collectors by narrative, photographs, and drawings, including collector materials, designs, dimension, and construction.

2. Thermal Performance Characteristics

- Collector efficiency curves (efficiency as a function of average fluid temperature or inlet coolant temperature, ambient air temperature, solar radiation normal to the collector, and wind speed) or equivalent collector performance indication (such as heat production) for several days that typify the full range of operation of the system.
- Pressure drop through collectors.
- Optical efficiency vs. incident angle, daily, monthly, and annual optical efficiency.*
- Thermal loss coefficient as a function of the difference between the ambient and the mean plate temperature, for known wind speeds.*

3. Lifetime Performance Characteristics

- Corrosion
- Leakage
- Hot spots
- Breakage

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*Optional Information to be included if known.

- Stability of collector working fluid

B. HEAT TRANSFER SUB-SYSTEM

1. Description of Physical Configuration

- Description of heat transfer sub-system by narrative, photographs, and drawings. Specify construction materials and working fluids.

2. Thermal Performance Characteristics*

- Inlet and outlet temperatures on both sides of exchanger.
- Inlet and outlet pressures on both sides of exchanger.
- Mass flow rates on both sides of exchanger.
- Pumping power.

C. THERMAL ENERGY STORAGE SUB-SYSTEM

1. Description of Physical Configuration

- Description of thermal energy storage sub-system by narrative, photographs, and drawings.
- Specify construction materials and working fluids, location within system, insulation details (material and construction), mass and volume of storage sub-system, storage duration and/or energy stored at same temperature.

2. Thermal Performance Characteristics*

- Mean temperature, hourly and daily, of the immediate surroundings.
- Thermal loss or gain, hourly and daily.
- Storage capacity.
- Inlet and outlet temperatures and pressures.
- Flow rates and pumping power.
- If phase change materials are used, specify compound and thermal characteristics.

D. AIR-CONDITIONING SUB-SYSTEM

1. Description of Physical Configuration

- Description of air-conditioning unit by narrative, photographs, and drawings.

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* Optional Information to be included if known.

* This information is of secondary importance in that it is this information that is used to determine the quantities reported in II A. If possible, it is suggested (optional) that a typical day be used to show:
  - Significant energy flow rates -- additions and losses.
  - Significant mass flow rates -- additions and losses.
  - Temperature and pressure at critical locations.
  - Temperature drop and pressure drop across major components.

- Type of sub-system -- heat pump, absorption, passive, etc.
- Heat rejection method.

2. Thermal Performance Characteristics

- Capacity at design inlet (to air-conditioning unit) temperature.**
- Capacity+ and coefficient of performance COP curves (inlet temperature as variable).**
- Sensitivity of the capacity and COP to variations in inlet temperature, evaporation temperature, wet and dry bulb temperature.

The International System (S.I.) will be used exclusively++ with the following recommendations:

Pressure - given in Kpa
Temperature - ^{o}C
Energy - MJ and/or Kwh
Solar Flow Rate - Kw, w
Solar Radiation - the intensity will be given in W/m^2, the hourly, daily, monthly or annual totals will be given in MJ/m^2 day averaged over a day, month, or year.
Wind Speed - m/sec
Mass Flow Rate - l/sec or kg/sec

** Condenser, absorber and evaporator temperatures should be stated.

+ Including the ratio of sensible to latent heat removal.

++ According to the resolutions of the Converence Generale des Poids et Mesures, 1960.

APPENDIX F

CCMS FORMAT SUMMARY OUTLINE FOR SUMMARIZING SOLAR HEATING AND COOLING SYSTEM PERFORMANCE

The objective of the Format Summary Outline is to enable an author to prepare a summary of a system performance report which provides the reader with information sufficient to enable him to understand the nature of the project, the principal features of the environment, building, and the solar heating and/or cooling system, as well as to give him a perspective on the month-by-month thermal performance of the system, and major economic factors. Details of system controls, operating modes, daily performance and economic projections are to be provided in the complete system performance report, prepared in accordance with the "CCMS System Reporting Format." Quantitative information is to be reported in the International System of Units.

I. GENERAL DESCRIPTION

I.A. Project: Name, Location, Objective(s), Brief Description* (Approximately 100 words)

I.B. Environment

- Latitude, Longitude and altitude of project
- Table of monthly averages of:
  - (1) Percent of sunshine or cloud cover fraction
  - (2) Mean daily solar radiation on surface of specified orientation
  - (3) Ambient temperature, dry bulb and wet bulb
  - (4) Heating degree days and cooling degree days
  - (5) Wind velocity

Table:

Month	(1)	(2)	(3)	(4)	(5)

I.C. System

o Highlights of Building and System Features (Approximately 50 words).

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* Note I.C., System Highlights

- One or two system diagrams.
- Major operating modes (approximately 50 words).
- Building Characteristics
    - Type of occupancy or use
    - Floor area heated and type of heating system
    - Design heat load per unit design temperature difference
    - Floor area cooled and type of cooling system
    - Design cooling load per unit design temperature difference
- Collector Characteristics
    - Typify in terms of applicable factors such as number of glazings, concentrator type, evacuation, selective surface, fluid type, reflective components
    - Freeze protection method
    - Normal maximum outlet temperature
    - Efficiency parameters $F_R \tau\alpha$ and loss coefficient
    - Location with respect to building
    - Orientation of collector plane or tracking axis orientation
- Hot-Side Storage Characteristics
    - Typify in terms of applicable items such as water, rock, phase-change material. Containment material. Heat exchange method.
    - Volume, weight, and normal maximum temperature
    - Location with respect to building
    - Gross heat capacity per degree or per phase change
    - Loss coefficient
- Cold-Side Characteristics
    - Typify in terms of applicable items such as water, rock, phase-change material. Containment material. Heat exchange method.
    - Volume, weight, and normal minimum temperature

    - Location with respect to building
    - Gross heat capacity per degree or per phase change
    - Loss coefficient
- Auxiliary Energy Supply Characteristics
    - Type
    - Capacity and efficiency
- Cooling Unit Characteristics
    - Type
    - Design Point
    - Capacity and COP at design point
    - Off-design operating range
- Service Hot Water System Characteristics
    - Normal load
    - Solar preheat or other arrangement. Heat exchanger type.
    - Tank sizes

II. SYSTEM THERMAL PERFORMANCE SUMMARY

II.A. Table of Monthly and Annual Averages of Mean Daily Energy Quantities, by Column Number

(1) Solar energy incident on plane of collectors
(2) Solar energy to hot-side storage
(3) Useful energy from hot-side storage
(4) Solar energy to space heating
(5) Auxiliary energy to space heating
(6) Heat recovery subsystem heat to space heating
(7) Solar energy to service hot water
(8) Auxiliary energy to service hot water
(9) Heat recovery subsystem heat to service hot water

(10) Solar energy to cooling

(11) Auxiliary energy to cooling

(12) Energy to cold-side storage

(13) Useful energy from cold-side storage

(14) Percent of heating and service hot water provided by solar energy

(15) Percent of cooling provided by solar energy

(16) Percent of heating and cooling provided by solar energy

(17) Electric energy to pumps and fans

(18) Number of days solar and data system were operating

Tabular format:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Month									
.									
.									
.									
Annual									

	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Month									
.									
.									
.									
Annual									

II.B. Departure from Desired Building Space Conditions

II.C. Degree to which Energy and Mass Balances were Achieved

II.D. Fuel Savings - Primary fuel type and monthly savings

III. SYSTEM ECONOMIC DATA

Costs: Labor, material, and total operating cost including supplemental energy.

IV. MAJOR CONCLUSIONS - Approximately 100 words

APPENDIX G

SYSTEM REPORTING FORMAT COMMITTEE

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APPENDIX H

REPORTS EXCHANGED SINCE SEPTEMBER 1976

AUSTRALIA	Solar Heating as a Major Source of Energy for Australia. By R. N. Morse. Paper presented at The Tenth World Energy Conference, Istanbul, Turkey, September 19-23, 1977.
	Final Report on the Performance of Three Australian Solar Hot Water Systems. By H. Salt. SES Report No. 9. July 1977.
CANADA	Continuation Study of Potential for Solar Heating in Canada, #77-02. Hollands and Orgill, University of Waterloo, August 1977.
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FEDERAL REPUBLIC OF GERMANY	Guidelines and Directions for Determining the Feasibility of Utilizing Solar Collectors: Efficiency Tests of Solar Collectors. Arbeitsgemeinschaft Solarenergie E.V., September 1976
	Energy R&D Program of the Federal Republic of Germany. Project Management for Energy Research-KFA Julich, Annual Report 1976.
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Storage for Low Temperature Heat: Solar Energy Thermal Storage. G. Wettermark and J. Kowalewska, Swedish Council for Building Research, September 1976.

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Solar Energy Utilization Related to the Heating and Cooling of Buildings in Turkey. Ministry of Energy and Natural Resources, 1976.

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UNITED STATES
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Assessment of Solar Heating and Cooling Technology. J.D. Balcomb and J. E. Perry, Los Alamos Scientific Lab., LA-6379-MS, May 1977.

ERDA's Pacific Regional Solar Heating Handbook. Los Alamos Scientific Lab, November 1976.

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Thermal Data Requirements and Performance Evaluation Procedures for the National Solar Heating and Cooling Demonstration Program. #NBSIR 76-1137, National Bureau of Standards, August 1976.

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Proceedings of the 1977 Flat-Plate Solar Collector Conference. February 28-March 2, 1977, Orlando, Florida.

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Results and Analysis of a Round-Robin Test Program for Liquid-Heating Flat-Plate Solar Collectors. NBS975, National Bureau of Standards, August 1978.

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